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APPLIED MECHANICS REVIEWS

VOL. 6, NO. 11 MARTIN GOLAND *Editor* NOVEMBER 1953

IN-SERVICE TRAINING FOR RESEARCH AND DEVELOPMENT

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THE following comments will be concerned primarily with engineering personnel who are engaged in research and development. The remarks may also apply to other scientific or nonprofessional employees, but their applicability to these individuals and groups has not been tested.

First, several definitions will be presented:

Research (1)[1] may be defined as the experimental determination of the behavior of a system (substance, circuit, etc.) in which the boundary conditions are fixed and all independent variables are under the control of the experimenter. The development of the postulates necessary to explain these results and to allow formulation and a rational presentation thereof is also research and is often designated as theoretical research.

Fundamental (sometimes called *basic*) *Research* is directed toward the extension of knowledge and its formulation. Research in this category is usually not pointed toward solving a practical problem, nor is it subject to a time schedule.

Foundation Research is defined as the experimental determination of the behavior of components of a system (the properties of a material or the nature of a phenomenon), which knowledge is necessary to the development or the design of a particular system.

Development is defined as the intuitive application of physical and biological phenomena, sturdily supported by analytical and experimental (pilot and prototype) solutions to the problem at hand, in order to produce a given device that will possess predetermined performance.

Design is the evolution of a plan for a system formed in the mind and conceived to satisfy all requirements placed upon the system. The requirements may be physical (for example, the proper strength), biological (for example, the maintenance of proper environment for life), economic and sociological, and may include all or combinations thereof. The results are usually presented graphically and numerically (specifications). Design may proceed along two channels, analytical or experimental; the latter, namely experimental design, is essentially development.

In terms of these definitions the objectives of research and development differ greatly, the latter being directed to the completion of a given object (system), while the results of the former may be considered as man's interpretation of nature and/or of man-made combinations of natural elements. Thus the thought processes involved in performing the two functions may be different. However, experimental research usually requires the development and assembly of the experimental equipment; this procedure resembles that of the development function. Again, the development function is certainly included in engineering; experimental design is coordinate with analytical design. The different research activities are distinguished from each other by motive, purpose, organization, and the system being studied.

The exercise of the development function (and to a much lesser extent, the research function) is a process of synthesis. The college training of young men is too often limited to reasoning involving analysis, and the process of synthesis must be included in an on-the-job training program.

An activity which will be called Engineering Systems Analysis and Synthesis would form the basis of this training regime. Through the elaboration of the process of maximation of the sequence representing the fruition of an idea as a consumer commodity and each step between, the contributions of research and/or development to the sequence are carefully delineated. Thus the contributions of research and development will be placed in their true perspective as a part of an elaborate sequence and can often be expressed quantitatively in terms of the independent variables: cost, time, materials, and men.

A general conclusion appears to follow, namely, that the worker in research may become a specialist (indicating depth of knowledge in a given area), while the development worker cannot by the very nature of his tasks allow himself to become a specialist. His breadth of knowledge must expand with increasing effectiveness.

A knowledge of the properties of materials is essential to the success of most research or development projects. For indeed it is often the chance choice of an available material which spells the success of the exploitation of the idea Or again the diligent search for a material with a given property or a given property variation with a variable of the system has resulted in a solution of the problem. There exists a need for a greater knowledge of properties and a better system of cataloguing these properties. Those data now available are scattered too widely for effective use. The availability of a broad storage system for properties utilizing digital computers is basic to the future of research and development.

The research and development functions both depend upon the utilization of the experimental method. On the road to the ultimate goal, the several approaches utilized may appear to be "cut" and "try," but these apparently diverse attacks on the problem are usually related in a rational experimental schema.

In both research and development, the initial steps involve devising alternate plans of attack. Thus the "design of the experiment" (a term used by statisticians) becomes an important first step in any project.

[1] Numbers in parentheses indicate References at end of paper.

Both feasibility studies and evaluation studies are essential steps in the initiation and progression of either research or development projects, respectively. However, the objective of the studies in a development project (4)[1] is broadened greatly by the inclusion of both the economic variables (values, costs, . . .) and the humanic variables (interaction of the system under consideration, and man). It will be countered, and correctly, that the several research approaches and indeed the necessity of a given research activity must often be subjected to economic scrutiny (2) and observed in terms of social need.

The design of the experiment for research (or the development plan), the feasibility studies, and the evaluation studies rest upon statistical methods. Thus basic training in Statistical Theory and applications and the Theory of Probability is another ingredient in the intellectual growth of the individual.

Both research and development require the attributes of creativeness and ingenuity. The extent to which the working (and the total) environment influences the productivity of the technical employee is being made the subject of serious study. But it is certain that, for each individual, a set of conditions (incentives, salary, physical environment, relations with other workers, freedom from routine duties, opportunity for reflection, etc.) exists which will result in the optimum productivity. This set of conditions each technical worker will wish to determine from sources in Industrial Relations, Business Administration, Psychology, and Engineering Management.

Research and Development may be conducted on an individual basis or through team effort or a combination thereof. The interrelationships of individuals and of group, the problems of communication and other elements of management bear greatly upon the effectiveness of the research and development organization. Communication of ideas and results is a keystone of an effective research and development organization. Although the responsibility of management in initiating, encouraging, and timing the flow of information is great, the position of the technical employee is central by virtue of being a receiver, a transmitter, and a link in the communication chain.

He must familiarize himself with the several modes of expression (oral and written), work to reduce technical language barriers between specialists, share ideas with others, seek information and techniques from cogent sources, etc.

In the writer's opinion, the study of the communication processes will be an important segment of the on-the-job training program.

A member of a research and/or development team works close to the boundaries of knowledge by virtue of the fact that he is bent upon extending these boundaries. Thus he will wish to be in close touch with changes on the front of knowledge, with incremental additions to experimental and analytical methodology, and with the additional data on material properties.

The sources of knowledge bearing upon research and development spring from centers of learning and from industry. The results of basic research mostly stem from the universities (the academic output of all departments, but in particular the Science and Engineering Departments) and are disseminated through publication, while the results of development are revealed as the works of industrial laboratories and industry. The transmission of information in the development function is difficult, has not been codified, and much ingenuity must be expended to increase its effectiveness.

Management has recognized that it shares the responsibility in the area of training of the individual. The essential segment of this training which involves preparations for the present and next assignment should be a part of the job. On-the-job training (3) is an integral part of the job itself. The combination of efforts of management, the college of engineering, and the technical employee (3) can develop and execute a program of on-the-job training and education which will materially increase the effectiveness of the research and development effort in the United States.

Present engineering curricula, including graduate programs, do not necessarily contain all of the disciplines implicit in the design, research, and development functions (as defined in this paper). Thus the engineering graduate will find it necessary to augment his school experiences through postgraduate training, preferably on-the-job training supplemented by off-the-job education.

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1 Boelter, L. M. K., Engineering research, *Mech. Engng.*, N. Y. **70,** 12, p. 978, Dec. 1948.

2 —A technique of problem solution, *J. Philosophy* **40,** 5, 127–132, Mar. 4, 1943.

3 —Looking ahead in engineering education, *J. Engng. Education* **43,** 4, 249–257, Dec. 1952.

4 —Some thoughts on the evaluation of research and development, Evaluating Research and Development, Institute of Industrial Relations, Univ. of Calif., Los Angeles, pp. 7–12.

Books Received for Review

The following books are being assigned reviewers. In the future, books will be listed in this section as they are received.

ENGLISCH, C., Verschleiss, Betriebszahlen und Wirtschaftlichkeit von Verbrennungskraftmaschinen, Wien, Springer-Verlag 1952, x + 288 pp. $12.40.

SMITHELLS, C. J., Tungsten—Its metallurgy, properties and applications, New York, Chemical Publ. Co., Inc., 1953, xii + 326 pp. $8.50.

GROSS, B., Mathematical structure of the theories of viscoelasticity, Paris, Hermann & Cie., 1953, 74 pp.

ENOS, G. M., and FONTAINE, W. E., Elements of heat treatment, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1953, 286 pp. $5.

DUNHAM, C. W., The theory and practice of reinforced concrete, 3rd ed., New York, McGraw-Hill Book Co., Inc., 1953, xiii + 499 pp. $7.

FRIES, W., Fachwerk und Rahmenwerk, Berlin, Springer-Verlag, 1953, x + 368 pp. DM 42.

SHORTLEY, G., and WILLIAMS, D., Elements of physics, New York, Prentice-Hall, Inc., 1953, xiii + 778 pp. $7.50.

PLETTA, D. H., Engineering statics and dynamics, New York, The Ronald Press Co., 1951, ix + 392 pp. $5.50.

MOORE, H. F., and MOORE, M. B., Textbook of the materials of engineering, 8th ed., New York, McGraw-Hill Book Co., Inc., 1953, ix + 372 pp. $6.

MENZEL, D. H., Mathematical physics, New York, Prentice-Hall, Inc., 1953, vii + 412 pp. $8.50.

HADEKEL, R., Displacement pumps and motors, London, Pitman & Sons, Ltd., 1951, vii + 170 pp. 25s.

BIEZENO, C. B., and GRAMMEL, R., Technische Dynamik. I. Grundlagen und Einzelne Maschinenteile; II. Dampfturbinen und Brennkraftmaschinen, Berlin, Springer-Verlag, 1953, xii + 699 pp., 413 figs.; viii + 452 pp., 315 figs. DM 66; DM 44.

MARQUARD, E., Schwingungsdynamik des schnellen Strassenfahrzeugs, Essen, Verlag W. Girardet, 1952, 228 pp. DM 20.

KRAMES, J. L., Darstellende und Kinematische Geometrie für Maschinenbauer, Wien, Franz Deuticke, 1952, viii + 267 pp., 306 figs., 2 tables. $2.90.

POST, G., and LONDE, P., Les barrages en terre compactée. Pratiques Americaines, Paris, Gauthier-Villars, 1953, 185 pp.

SHAW, F. S., An introduction to relaxation methods, New York, Dover Publications, Inc., 396 pp. $5.50.

GERASSIMOW, S. G., Automatische Regelung von Kesselanlagen, Berlin, Verlag Technik, 1952, viii + 353 pp. $8.40.

RAŠKOVIĆ, D., Mekhanika. II. Kinematika, Belgrade, Izd. Pred. Narod. Repub. Srbije, 1950, xvi + 288 pp.

KAZAKEVICH, N. L., Moshchnie skorostnie zubchatie peredachi, Moscow, Gosud. Nauch.-Tekh. Izd. Mash. Lit., 1950, 208 pp.

CZUDAKOV, E. A., edited by, Podveska Avtomobilva, Moscow, Izdat. Akad. Nauk SSSR, 1951, 275 pp.

Communications

Concerning AMR 6, Rev. 2739 (Sept. 1953): R. G. Noel, Elastic stability of simply supported flat rectangular plates under critical combinations of longitudinal bending, longitudinal compression, and lateral compression

Reviewer notes that in the Reader's Forum of *J. aero. Sci.* **20**, 6, p. 440, June 1953, the misprints mentioned in the review have been corrected by the author according to reviewer's suggestion.

G. C. K. Yeh, USA

Theoretical and Experimental Methods

3284. Caligo, D., On a class of nonlinear differential equations (in Italian), *Cons. naz. Ric.* no. 342, 24 pp., 1952 = *Mem. Accad. Sci. Torino* (3a) **1**, part I.

This very interesting work shows a method for solving some nonlinear homogeneous differential equations of second and third order with constant coefficients. It is applied in detail to equations of the second and third grade. This method consists essentially in interpreting the differential equations, i.e., $\phi(y'', y', y) = 0$, as equations of a plane curve in homogeneous coordinates y'', y', y. By substituting $w = y''/y$ and $v = y'/y$, the last equations are transformed in $\phi(w, v, 1) = 0$. A parametric representation of this curve shows a system of equations $w = w(\delta)$ and $v = v(\delta)$, δ being the parameter. As the last equation is of separate variables and first order, we may easily obtain $\delta = \delta(t)$ by imposing the conditions $dv/dt = v' = w - v^2$ and integrating. It is then very easy to obtain $v = v(t)$ and, by applying $v = y'/y$, also the function required $y = y(t)$.

The author gives a very careful study of the equations $a_{11}y''^2 + 2a_{12}y''y' + a_{22}y'^2 + 2a_{13}y''y + 2a_{23}y'y + a_{33}y^2 = 0$, basing his classifications on that applied to the conics. He also indicates an alternative method for integrating this equation and analyzes the singularity of the solutions. The results obtained by this method coincide with those obtained by the more general methods of other authors (Ince, Kamke, etc.).

J. N. Aguirre, Argentina

3285. Hartman, P., and Wintner, A., On the behavior of the solutions of real binary differential systems at singular points, *Amer. J. Math.* **75**, 1, 117–126, Jan. 1953.

If the system $x' = f(x, y)$, $y' = g(x, y)$ [1] satisfies the conditions: (i), f, g continuous on $x^2 + y^2 \leqq$ const, (ii), if Ω^* is a closed set with period 2π containing no interval and $F(t) = \lim_{r \to 0} [f(r \cos \theta, r \sin \theta)]/r$, $G(t) = [g(r \cos \theta, r \sin \theta)]/r$, exist uniformly on every closed interval not containing a point of Ω^* and $F^2(\theta) + G^2(\theta) > 0$ for θ not in Ω^*, (iii) if the set Ω^0 of θ values, not in Ω^* with $T(\theta) = G \cos \theta - F \sin \theta = 0$, is either empty or an infinite sequence with no cluster valve in the complement of Ω^*, then the following theorems are proved by methods developed in previous papers: (1) If Γ is a solution path of $x' = f$, $y' = g$, reaching the origin with $\lim \theta = \theta_0$, then θ_0 is either in Ω^* or in Ω^0. In the latter case $\lim \operatorname{arc\,tg}\, y'/x' = \theta_0$. (2) If θ_0 does not exist, then Γ is a spiral, i.e., $|\theta(t)| \to \infty$. (3) If $T(\theta)$ changes sign at $\theta = \theta_0$ of Ω^0, then [1] has at least one solution path, reaching the origin for which θ_0 exists. (4) If $T(\theta)$ assumes both positive and negative values, for every solution path reaching the origin, θ_0 exists. In particular, the case $x' = \alpha x + \beta y + f^*$, $y' = \gamma x + \delta y + g^*$ is considered and results are compared with classical results.

R. Timman, Holland

3286. Wannier, G. H., Connection formulas between the solutions of Mathieu's equation, *Quart. appl. Math.* **11**, 1, 33–59, Apr. 1953.

Formulas are obtained which relate two groups of solutions of the Mathieu equation. The first group consists of four functions which are called the Lindemann-Stieltjes functions. They are the solutions which reduce to the Mathieu functions whenever periodic solutions exist. The second group is made up of four other solutions which are characterized by their asymptotic behavior. For large values of their arguments they behave more specifically as $K_\alpha(k \exp y)$, where K_α is the modified Bessel function of the second and of suitable order α. The formulas connecting the functions of these two groups are derived. A parameter Φ is introduced for this purpose which is new in this theory. It is shown that Φ is a rather slowly varying function of the constants of the Mathieu equation. Its relation to the Floquet constant is derived, and it is pointed out that it can be used to establish an upper limit for the absolute value of that constant.

R. Drenick, USA

3287. Bilinski, S., The Dirac function and an elementary problem of hydrostatics (in Croatian), *Glas. Mat.-Fiz. Astr.* (2) **7**, 4, 219–227, 1952.

By introducing the term "partial pressure" as that part of the hydrostatic pressure on the bottom which is caused by a particle of unit mass in any point of the fluid, the resulting hydrostatic pressure can be expressed by a volume integral. The formula for partial pressure is obtained by considering the fluid as consisting of equal circular cylinders and by taking the limit of the expression for the pressure when the cylinder radius is converging to zero. It is shown that under these assumptions the partial pressure is given by the Dirac δ function, which is given by: $\delta(x) = 0$ for $x \neq 0$, and $\delta(0) \to \infty$ so that $\int_{-\infty}^{+\infty} \delta(x)\,dx = 1$. From this, the known expression for the resulting pressure on a part of the bottom follows immediately.

Reviewer's opinion is that the above treatment is of a limited interest, in so far as it only shows how the δ function can be introduced in this part of physics.

A. Kuhelj, Yugoslavia

3288. Hsiang, F. C., On the integro-jump of a function and its Fourier coefficients, *Bull. Calcutta Math. Soc.* **44**, 2, 55–58, June 1952.

Using several results due to Szasz, author proves that (a) the existence of the integral $\Psi_n(x,t) = \int_0^t \psi(x, u)du/u^{1+\eta}$ $(\eta > 0)$ implies (1) $\lim_{n \to \infty} (\tilde{\sigma}_{2n}(x) - \tilde{\sigma}_n(x)) = D(x) \log 2/\pi$, and (b) the

condition $\Psi(x, t) = {}_c\int^t \psi(x, t)dt = 0$ $(t/\log 1/t)$ $(t \to +0)$ also implies (1), where $\psi(x, t) = f(x + t) - f(x - t) - D(x)$, $D(x)$ is the integro-jump of the function $f(t)$, $\bar{\sigma}_n = \sum_1^n \bar{S}_n/n$, and $\bar{S}_n = \sum_{\nu=1}^{\infty} (b_\nu \cos \nu t - a_\nu \sin \nu t)$. E. J. Scott, USA

3289. Newns, W. F., On the representation of analytic functions by infinite series, *Phil. Trans. roy. Soc. Lond.* (*A*) **245,** 900, 429–468, Feb. 1953.

The basic problem discussed here is as follows: Let E be a vector space over the field of complex numbers and let $f \in E$. Under what conditions can f be represented by a Cannon's series, i.e., a series of the form $\sum_{k=0}^{\infty} \pi_k f(o) p_k(z)$. The functions $p_k(z)$ are not necessarily polynomials. The concept of convergence in E obtains from the mode of representation required. The author is led to construct a topology on E for this convergence.

If the topology is defined by a countable set of seminorms, such that the first Hausdorff axiom of countability is satisfied, then from the results of Birkhoff and Wehausen, the space E can be metrized with an F-metric. Besides the first stated problem, the significant question on the uniqueness of representation arises. For certain open sets (i.e., open circles at the origin) it is known from previous investigations that the answer is in the affirmative, and for closed circles the author shows that the answer is in the negative.

The author is careful to point out that if $f \in E$ is represented by the above series, this does not mean to say that all such f are represented by some series of the form $\sum_{k=0}^{\infty} \alpha_k p_k(z)$. This is demonstrated by a simple counter example.

The paper is divided into three parts, the first of which concerns the topological preliminaries, the second part lays down the general theory of basic series (Whittaker), and the third considers the basic sets associated with given sets. Some of the pertinent results are too complicated to reproduce here.

J. J. Brandstatter, USA

3290. Albrecht, J., Taylor series and finite expressions for Δu and $\Delta\Delta u$ (in German), *ZAMM* **33,** 1/2, 41–48, Jan./Feb. 1953.

The Taylor series expansion of a general statement that leads to finite-difference approximations of Δu and $\Delta\Delta u$ (where Δ is the Laplacian operator) is brought into a clear form by a suitable composition of the partial derivatives. Thus it is easy to survey the possibilities of the procedure; that is, it is easily determined what the highest order of the error will be for given grid points or what the least number of points necessary for an error of a given order should be. The author discusses regular grids of squares, triangles, hexagons, and cubes. S. Ostrach, USA

3291. Picone, M., General aspects of interpolation and some possible further research (in French), *Cons. naz. Ric.* no. 360, 20 pp., 1953 = *R. C. Circ. Mat. Palermo* (2) **1, 2,** 1952.

In interpolation, numerical integration, etc., one wishes to evaluate a certain functional $\Lambda[f]$ of a function f, where $\Lambda[f]$ may represent $f(x)$ for a particular x, or a definite integral of f, or may have other interpretations. One, in fact, evaluates $\Lambda[u]$ where u is selected by some criteria from among a suitable class of functions as an approximation to f. Then, under fairly general conditions, it is possible to express the error $\Lambda[f] - \Lambda[u]$ in the form

$$\int \Gamma_\Lambda(x) E[f] dx$$

where Γ_Λ depends only upon the functional Λ and is independent of the particular function f; $E[f]$ depends upon f and upon the criteria for selecting u, but is independent of Λ [Sard, *Duke math. J.* **15,** 333, 1948; Milne, W. E., AMR **4,** Rev. 1]. Author gives expressions for the error for various integration formulas in several dimensions, and raises some unsolved problems.

A. S. Householder, USA

3292. Matthieu, P., On error estimation in the Adams extrapolation procedure (in German), *ZAMM* **33,** 1/2, 26–41, Jan./Feb. 1953.

This is a straightforward extension to equations of higher order of author's earlier results on the first-order differential equation [AMR **5,** Rev. 1924]. As before, the given equation is approximately linearized with respect to the error of an approximation. This linear error equation serves to find an estimate for the error. A special estimate, based on the nature of the disturbance function of the error equation, is made with respect to the Adams extrapolation method. H. Bückner, USA

3293. Arf, C., On the analogy between a free boundary problem of elasticity theory and a problem of fluid flow (in French), *Bull. tech. Univ. Istanbul* **4,** 1, 1–4, 1951.

It is shown that flow problems involving free boundaries are analogous to some problems in elasticity where the free-stream boundary is free from traction. The case of flow out of a two-dimensional orifice is discussed, and the corresponding traction to be applied to the flow boundary is obtained.

B. R. Seth, India

3294. Sawyer, J. S., and Bushby, F. H., A baroclinic model atmosphere suitable for numerical integration, *J. Meteor.* **10,** 1, 54–59, Feb. 1953.

The vorticity and continuity equations and the adiabatic law are solved with numerous assumptions to yield a system of three partial-differential equations. The dependent variables are the height of some upper-level pressure surface, the thickness of the layer from 1000 millibars to that surface, and the average vertical motion in the column. The model, similar to that proposed independently by N. Phillips of the Institute for Advanced Study at Princeton, N. J., has been demonstrated by Phillips to be more successful than earlier barotropic models. L. Machta, USA

3295. Schneider, P. J., Numerical method for porous heat sources, *J. appl. Phys.* **24,** 3, 271–274, Mar. 1953.

A numerical method is presented for calculating the temperature field in heat-transfer problems in which a gas or fluid passes through a porous wall containing a nonuniform heat source. Analytical solutions to many problems of this type are known but are assumed to be awkward for numerical evaluation. A comparison between the numerical method and the exact solution is given for a particular problem having uniform heat source. The analytical solution is exceedingly simple in this case and may be easily evaluated numerically. The comparison given is very favorable. G. W. Evans, II, USA

3296. Korn, G. A., The difference analyzer: a simple differential equation solver, *Math. Tables Aids Comput.* **6,** 37, 1–8, Jan. 1952.

Paper describes a differential equation analyzer based upon theory of small step variations of the independent variable. It requires function potentiometers and summing networks to represent functions in first-order differential equation. Author asserts device can be constructed at low cost. With addition of servo-

mechanisms and step motors, the analyzer can be made automatic. Error estimates are given for case where solution is bounded in a region. Author asserts device yields slide-rule accuracy.

T. Caywood, USA

3297. **Wolf, J. J., The Office of Naval Research relay computer,** *Math. Tables Aids Comput.* **6,** 40, 207–212, Oct. 1952.

Paper describes a comparatively slow-speed, single-address digital computer which has been in continuous operation at the George Washington University since May 1951. The computer incorporates a magnetic storage drum capable of storing 4094 numbers or instructions, each of 24 binary digits; 734 mechanical relays which comprise the arithmetic section; and 655 vacuum tubes. Forty-two instructions can be used. During the first year of operation the computer was available to the mathematicians for 55% of the total time; this proportion was subsequently increased to 68%. Paper lists several problems which have been solved by the computer. A. Porter, Canada

3298. **Dubois, Fr., Automatic computation of railway train schedules,** *Engineering* **174,** 4532, 717–719, Dec. 1952.

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 3525, 3559)

✎3299. **Roy, L., Problems in graphical statics and strength of materials [Problèmes de statique graphique et de résistance des matériaux],** Paris, Gauthier-Villars, 1950, xii + 138 pp.

Book is a revised second edition of a volume originally written in 1928 to supplement a text by the same author. Both books apparently have been used in undergraduate courses in mechanics of materials at the University of Toulouse for many years. Problems range from graphical determination of shears and bending moments in beams, to columns and simple indeterminate structures. Reviewer notes with approval that the method of sections for solving trusses is given precedence over its corollary, the method of joints—something many American texts fail to do.

A. D. Topping, USA

✎3300. **Loĭtsianskiĭ, L. G., and Lur′e, A. I., Course in theoretical mechanics. I. Statics and kinematics [Kurs teoreticheskoĭ mekhaniki. I. Statika i kinematika],** Moscow-Leningrad, Gosud. Izd. Tekh.-Teor. Lit., 1948, 399 pp.

Authors revised and enlarged this fourth edition of their detailed tract on statics and kinematics. Development is historical and classical with extensive use made of vector notations and algebra. New vector operations are introduced in the text where needed. Theory of text is bolstered with numerous worked-out examples of practical applications. Two parts of this volume comprise 14 chapters, divided into 83 subsections. Chapter headings are: 1. Basic properties of forces applied to material bodies; 2. Equilibrium of bodies under action of conservative system of forces; 3. Equilibrium of bodies under action of systems of forces applied in one plane; 4. Graphical statics and calculations of bars; 5. Nonconservative force systems in space; 6. Center of parallel forces and center of gravity; 7. Motion of a point in space; 8. Velocity and acceleration; 9. Kinematics of a point in curvilinear coordinates; 10. Simplest case of rigid body motion; 11. Plane rigid body motion; 12. Rigid body rotation around a fixed center and general case of rigid body motion; 13. Relative motion; 14. Addition of rotations. Revisions include section on history, development, and proof of theorem of parallelogram of forces, introduction of rolling friction, consideration of problems where solution is in form of inequalities, emphasis on difference between instantaneous center and those points of the rigid body through which the center passes at any instant, analytic proof of theorem of rolling centroid. M. D. Friedman, USA

✎3301. **Loĭtsianskiĭ, L. G., and Lur′e, A. I., Course in theoretical mechanics. II. Dynamics [Kurs teoreticheskoĭ mekhaniki. II. Dinamika],** Moscow-Leningrad, Gosud. Izd. Tekh.-Teor. Lit., 1948, 580 pp.

This second volume (see preceding review) covers field of dynamics in an additional 14 chapters, divided into 91 subsections. This volume was revised to emphasize applications to airplane motion. Additions in this edition are the Ritz method to solve dynamics problems, use of phase plane plots in vibration theory, use of momentum theorems in problems of motion of continua, and basis of Lyapunov stability theory for use in automatic regulation theory. Again included are worked examples applying theory to practical problems. Chapters are entitled: 15. Basic concepts of dynamics and Newton's law; 16. Basic equations of dynamics of a material point and methods of integrating them; 17. Basic theorems of dynamics. Theorem on variation of momentum; 18. Moment of momentum theorems; 19. Variation of kinetic energy theorems; 20. Principle of possible displacements; 21. D'Alembert's principle; 22. Elements of analytic mechanics; 23. Dynamics of relative motion; 24. Rigid body dynamics; 25. Dynamics of points and rigid bodies of variable mass; 26. Theory of small oscillations of systems with one degree of freedom; 27. Oscillations of systems with many degrees of freedom; 28. On stability of motion.

M. D. Friedman, USA

3302. **Zeuli, T., Corresponding dynamic systems involving forces which are linear functions of the velocity and admit treatment by means of the Lagrange equations** (in Italian), *Atti Sem. Mat. Fis. Univ. Modena* **5,** 146–151, 1950–1951.

Two dynamic systems with n rigid body degrees of freedom are called "corresponding" systems if they have the same "trajectories." The time history for passing through this trajectory may be different for the two systems.

The author investigates the relation which exists between the Lagrangian functions of two corresponding systems if the forces are linear functions of the velocity. He finds that the Lagrangian function of the second system is equal to the transformed Lagrangian function of the first system multiplied by a function defining the transformation of the time scales of the two systems.

G. W. Braun, USA

3303. **Dobronravov, V. V., On the application of the method of nonholonomic coordinates to certain questions of the mechanics of continuous media** (in Russian), *Vestnik Moskov. Univ. Ser. Fiz.-Mat. Estest. Nauk* **1950,** no. 9, 31–35, 1950.

Author determines the vector fields satisfying the equation $a = k$ curl a, with k an arbitrary point function. The reviewer fails to see why it is pertinent to mention anholonomic coordinates in this connection. On the contrary, when the coordinates used are anholonomic, the integration theory of the first-order partial equations used by the author does not apply.

A. W. Wundheiler, USA

3304. **Dobronravov, V. V., On some questions of the mechanics of nonholonomic systems** (in Russian), *Prikl. Mat. Mekh.* **16,** 6, 760–764, Nov./Dec. 1952.

Author defends himself against the charge [Neĭmark and Fufaev, AMR **5,** Rev. 1623] that his generalization of the Jacobi equation to anholonomic coordinates was based on improper use

of the commutativity condition (A) $d\delta x^i = \delta dx^i$. His defense consists in arguing that the same relation was applied by other men, including the reviewer. The latter does not agree: the pertinent paper [*Prace Mat.-Fiz.* **38**, 129–146, 1931] contains a section proving that (A) is necessary and sufficient for holonomicity. A. W. Wundheiler, USA

3305. Steward, G. C., On certain configurations of the cardinal points in plane kinematics, *Acta Math.* **88,** 371–383, 1952.

The set of cardinal points A_n in the fixed plane and the set A_n' in the moving plane are the instantaneous centers of rotation, of velocity, and of the successive orders of acceleration. If $\sigma_{n,r} = (-1)^{r+1}\binom{n}{r}$, and masses proportional to $\sigma_{n,r}$ are placed at A_r for $r = 1, 2, 3, \ldots, n$, then A_n' coincides with their center of mass. Relations among the centrodes, the paths of the A_n and A_n', are derived analytically by the use of complex operators. As special cases, it is shown that if the cardinal points of a set lie on a straight line, alternately on two perpendicular straight lines, on a logarithmic spiral, or at the vertexes of a spiral rectangular polygon (an orthogonal set), then these configurations are preserved during the motion. The motions associated with these configurations are discussed. A comparable treatment of these cardinal points is given by Bereis [AMR **4**, Rev. 4376; **6**, Rev. 2421].
M. Goldberg, USA

3306. Rosenauer, N., and Willis, A. H., Kinematics of mechanisms, Sydney, Australia, Associated General Publ. Pty. Ltd., xv + 395 pp., 377 figs. £ (Aust.) 4/10/0.

This book resembles German texts in content and will be most valuable for the material not previously available in English texts. The bulk of the book consists of an exhaustive treatment of the Euler-Savary equation, the Bobillier and Hartmann constructions, velocity analysis, and acceleration analysis. The final chapter provides an introduction to size synthesis, and an earlier chapter contains material frequently called "number" synthesis.

Reviewer highly recommends this as supplementary reading for those whose previous acquaintance with the subject has been limited to American and English texts. A. S. Hall, USA

3307. Wundheiler, A. W., Some formulas for bar linkages, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 19–22, 1952.

The paper attempts a partial linearization of precision design of all-pivot bar linkages, by introducing certain functions M_k^z and N_k^z of the bar directions ϕ_k, to replace the nonlinear involvement of these angles. The functions M and N are defined by the linkage structure alone, and are quotients of determinants whose terms are $\cos\phi_k$, $\sin\phi_k$, or zero. The angular corrections $\Delta\phi_k$ (multiplied by the bar lengths $l_k\Delta\phi_k$) are bilinear in the M's and N's and the bar-length corrections Δl_k. The bar lengths are linear in the M's and N's. The formulas are designed with large bar numbers in mind.

Assuming a crank velocity of one, the angular velocities ϕ_k are given as quotients of expressions bilinear in the M's and N's, $\cos t$ and $\sin t$. Thus a differential equation is obtained for all the functions generated by the rotation of the bars, for a given linkage structure.

To express design conditions of higher contact, higher derivatives are necessary. An algorithm is developed for the computation of these derivatives by recurrence, the formulas being standard for a given structure. It is shown that these conditions are expressible linearly in terms of certain (structure-standard) differential forms in the ϕ's.
From author's summary by W. J. Carter, USA

3308. Bergsträsser, M., Involute geometry of spur gear systems (in German), *VDI-Forschungsheft* **436,** 24 pp., 38 pp. of tables, 1952.

To avoid undercut in the pinion, we may increase the pressure angle (from α_0 to α_v) and enlarge the center distance (from a_0 to a_v). Following relations are well known: Total correction $m(x_1 + x_2) = a_0F_1(\alpha_0, \alpha_v)$, new center distance $a_v = a_0F_2(\alpha_0, \alpha_v)$; the essential part of the paper is a comprehensive tabulation of these functions F_1 and F_2 (36 pages). Reviewer believes that, in many cases, it would be quite as easy to use more direct relations, as mentioned, e.g., in Bosch: "Kraftfahrtechnisches Taschenbuch." And why totally reject the use of negative correction in the great wheel, when this method is used to a large extent in the British Standards? A. R. Holm, Denmark

3309. Dilgan, H., On the mean velocity of planets (in French), *Bull. tech. Univ. Istanbul* **4,** 1, 21–24, 1951.

Mean velocity of a planet in a Keplerian orbit is shown to be $(2\pi/T)\rho_b$, approximately, where T is period, and ρ_b is radius of curvature at end of minor axis. This velocity is arithmetic mean of velocities at perihelion and aphelion. S. Kirkby, England

3310. Krause, H., Motion of a space station along an elliptic path inclined to the equatorial plane of the earth (in German), *Weltraumfahrt* nos. 1, 3; 17–25, 74–79, Jan., July 1952.

This mathematical analysis of the orbital motion of a satellite extends the usual treatment of oribts to include the determination of such items as the time of passage through the earth shadow and the region of the earth surface observable from the satellite. Formulas for these and other orbit characteristics are derived, using the elementary principles of mechanics. A numerical example is given in which the orbital plane is at an angle of 45.18° to the equator, the perigee a distance of 7963.56 km from the center of the earth, and the eccentricity 0.198.
J. Lorell, USA

3311. de Pater, A. D., Stability of a bicone performing vibrations on a straight track (in French), Anniv. Vol. appl. Mech., dedicated to C. B. Biezeno; Haarlem, Antwerpen, Djakarta, N. V. De Technische Uitgeverij H. Stam, 1953, pp. 151–174. Hfl. 20.

An axle-and-wheels unit riding on a perfectly straight track is considered. This is preliminary to an article to be published later on the stability of a complete railway vehicle. The author considers gyroscopic forces that were not included by previous investigators and makes use of some recent model tests to evaluate the friction forces between wheel and rail. The assumption is made that there is no restraint on the axle except for the spring forces, and these are assumed constant. It is found for small disturbances that the ordinary axle-and-wheels unit (idealized as a double cone) has longitudinal stability but has lateral instability except at the very lowest rolling speeds.
W. C. Johnson, Jr., USA

3312. Criner, H. E., and McCann, G. D., Rails on elastic foundations under the influence of high-speed traveling loads, *J. appl. Mech.* **20,** 1, 13–22, Mar. 1953.

Methods and technique used on an electric analog computer are developed. A correspondence between electrical and mechanical quantities is established. The procedure is applied to the solution of beams of nonuniform characteristics, with the variation of magnitude and of velocity of traveling loads, and with variation of the elastic constants and damping coefficients. An illustrative example and numerous carefully prepared diagrams clarify the methods used in solving the problems.
W. Ornstein, USA

Gyroscopics, Governors, Servos

3313. Lefèvre, P., Study of the stability of linear systems by the method of the generalized phase diagram (in French), *Mém. Artill. fr.* **26**, 3, 503–588, 1952.

This paper deals with an extension of the Nyquist criterion with a view to making its use simpler, particularly in connection with linear systems of a relatively high order. Author indicates two approaches to this objective: the graphical and the analytical. The first occupies the first six chapters (62 pages) and the second is developed in chapter VII (13 pages).

Author shows that the Nyquist diagram is a particular case of a more general method based on Cauchy's theorem of residues. Starting from this point, he establishes what he calls the generalized phase diagram (g.p.d.) which he uses later. The diagram of amplitudes plays a less important role and appears only at some critical points of the g.p.d. Having established these concepts, author proceeds with their applications. It is shown that, owing to the logarithmic scale for amplitudes and linear for phases, addition of new elements in a closed loop is obtained by a simple addition of ordinates. In chapter III, the method is simplified by certain symmetry considerations and reduced to the analysis of the slope of a certain "transmittance curve." In chapter IV, the method is used for establishing the existence of an "essential instability" (of the saddle-point type), and in chapters V and VI it is used to establish the intervals of stability. The last chapter (VII) deals with the analytical method derived from the g.p.d. Here the determination of stability is reduced to that of real positive roots of a certain auxiliary equation.

It is impossible to give a more detailed account here, but, in reviewer's opinion, the clarity of the exposition, numerous examples, and the elegance with which author establishes connections between the graphical and analytical methods render the paper very valuable to those who are interested in advanced problems of automatic regulation and control.

N. Minorsky, France

3314. Erugin, N. P., On a problem of the theory of stability of automatic regulation systems (in Russian), *Prikl. Mat. Mekh.* 16, 5, 620–628, Sept./Oct. 1952.

Author considers the problem of the boundedness of the solutions of the system $dx/dt = f(x) + ay$, $dy/dt = bx + cy$, on the basis of certain assumptions concerning $f(x)$.

R. Bellman, USA

3315. Marble, F. E., and Cox, D. W., Jr., Servo-stabilization of low-frequency oscillations in a liquid bipropellant rocket motor, *J. Amer. Rocket Soc.* **23**, 2, 63–74, 81, Mar.-Apr. 1953.

Analysis is presented extending work of H. S. Tsien to the liquid bipropellant case. Such servo-stabilization would remove unnecessary restrictions on rocket design and allow concentration in design on rocket performance. Combustion time lags and residence time lags are included in the linearized analysis, and stability studies are based on Nyquist's criteria using a Satche diagram technique. It is concluded that the low-frequency oscillations can be servo-stabilized, and methods are shown for analyzing a projected rocket configuration for possible instability and finding the design constants for the feed-back servo, if required.

J. C. Sanders, USA

3316. Wittrick, W. H., Part I; Wittrick, W. H., Myers, D. M., and Blunden, Part II. Stability of a bimetallic disk, *Quart. J. Mech. appl. Math.* **6**, part 1, 15–31, Mar. 1953.

The general theory of the deformation of a bimetallic disk, with a small initial curvature due to temperature changes, is developed and applied to the case of a disk initially in the form of a spherical cap. It is shown that, if the central rise of the disk is initially greater than about twice the total thickness, a position of instability will occur on both heating and cooling. An expression is derived for the mean temperature which a disk of this type will maintain when used as the control element of a thermostat, and results are obtained for the temperature variation about this mean value.

From authors' summary by L. S. Dzung, Switzerland

Vibrations, Balancing

(See also Rev. 3311)

3317. Hayashi, C., Forced oscillations with nonlinear restoring force, *J. appl. Phys.* **24**, 2, 198–207, Feb. 1953.

Paper describes a method for the solution of a nonlinear differential equation of the type $\ddot{v} + k\dot{v} + f(v) = B\cos(t)$. By the use of the method of variation of parameters, the equation is transformed into a form which can be studied by the methods of Poincaré and Bendixon. The transient and periodic states of the solutions are studied and the stability of the periodic solutions is determined. The effect of initial conditions on the final periodic steady state is determined and harmonic as well as subharmonic oscillations are investigated. Theoretical results are compared with experimental measurements made on an electric circuit with a nonlinear inductor and are found to be in satisfactory agreement.

L. A. Pipes, USA

3318. Ludeke, C. A., and Pong, W., The extinction of predominantly subharmonic oscillations in nonlinear systems, *J. appl. Phys.* **24**, 1, 96–97, Jan. 1953.

This paper explains the use of an electromechanical analog to examine limiting values of certain parameters needed to destroy the subharmonic oscillation of $^1/_3$ order, of the nonlinear system $\ddot{\theta} + c\dot{\theta} + \alpha\theta + \beta\theta^3 = H\cos\omega t - G\sin\omega t$. Experiments were performed by increasing c and by decreasing ω. The results are in good agreement with the theory.

A. C. Eringen, USA

3319. Hayashi, C., Stability investigation of the nonlinear periodic oscillations, *J. appl. Phys.* **24**, 3, 344–348, Mar. 1953.

Stability for the solutions of nonlinear differential equations of type $d^2v/dt^2 + f(v)dv/dt + g(v) = e(t)$, $e(t + T) = e(t)$, is discussed by solving an equation which characterizes small variations from the periodic states of equilibrium. This latter equation leads to a linear equation in which the coefficient is periodic in the time. When all solutions of this equation are bounded, the oscillation is said to be stable; otherwise it is unstable. The characteristic exponents for the unbounded solutions are calculated by Whittaker's method, and the generalized stability condition is derived by comparing these with the damping of the system. The investigation is compared with one made by Mandelstam and Papalexi of stability conditions for subharmonic oscillations. An appendix to the paper calculates characteristic exponents for unbounded solutions of the variational equation when the periodic coefficient involves both sine and cosine series.

W. M. Whyburn, USA

3320. Klotter, K., and Pinney, E., A comprehensive stability criterion for forced vibrations in nonlinear systems, *J. appl. Mech.* **20**, 1, 9–12, Mar. 1953.

Author develops and discusses a set of equations which may be used to predict the stability of motion of vibrations of a system

defined by $a\ddot{q} + cq + c\phi(q, \dot{q}) = P \cos \Omega t$ where ϕ is a nonlinear function of q and/or $\dot{q}$. Stability depends on the sign of the rate of change of the maximum value of q, within the period, with respect to P. Motion is stable only when $\partial q_{max}/\partial P$ is positive. Procedure is applied to a particular type of nonlinear behavior to illustrate the method. W. J. Worley, USA

3321. Kreĭn, M. G., On certain new problems in the theory of vibration of string systems (in Russian), *Prikl. Mat. Mekh.* **16,** 5, 555–568, Sept./Oct. 1952.

Author investigates the problem of a vibrating string supporting a discrete number of masses and fastened in different manners at its ends. He proposes to establish conditions under which the frequencies coincide with a set of positive numbers $p_1 < p_2 < p_3 < \ldots$, given in advance. It is shown that the solution of this problem reduces to the establishment of the lower limit for the frequency p_{n+1} once the first n frequencies are determined. The calculation is carried out in three cases: (1) Both ends of the string are fastened; (2) one end is fastened and the other is free; (3) both ends are free. The major part of the paper is devoted to calculations by means of continued fractions, and cannot be abstracted. Once this problem is solved, author introduces additional restrictions for the minimum of the total mass. The last section deals with the passage to the limit when the number of discrete masses increases indefinitely so that the problem becomes that of a continuous string. N. Minorsky, France

3322. Volterra, E., On the response to external loads of continuous elastic systems with hereditary damping characteristics, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 57–63, 1952.

Author extends previous work [AMR **4,** Rev. 2820] to include arbitrary loading of strings, beams, and membranes. Expressions for steady-state motion and energy dissipation are given for arbitrary hereditary function. For hereditary damping of the first degree, results are presented graphically and compared with viscous damping. A. I. Bellin, USA

3323. Pringle, O. A., Use of the centrifugal governor mechanism as a torsional vibration absorber, *Trans. ASME* **75,** 1, 59–61, Jan. 1953.

A novel dynamic damper for vibrations is described. An elastically supported mass is constrained to move in a radial direction only. Natural frequency of this mass may be tuned to that of the torsional vibrations. Corioli's acceleration then produces tangential inertia forces to react torsional vibrations.

Equations of motion are derived. A tentative practical design is presented. Proposed damper is compared with conventional rotating turbulence-type absorber and appears to be more effective for low frequencies. C. D. Pengelley, USA

3324. Lo, H., and Renbarger, J. L., Bending vibrations of a rotating beam, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 75–79, 1952.

The problem treated is that of a nonuniform beam attached radially to a rotating hub and vibrating in a plane forming the angle β with the axis of rotation. The integrodifferential equation is derived by a vector method. By neglecting Corioli's acceleration, a linear equation is obtained. From this the interesting result is obtained that the mode shapes of the natural bending vibrations are identical regardless of the orientation of the plane of rotation, and that the natural frequency can be obtained from the simple equation $\omega^2 = \omega_L{}^2 - \Omega^2 \sin^2 \beta$, in which ω is the natural angular frequency for any value of β, ω_L the natural angular frequency for vibrations in an axial plane, and Ω the angular velocity of the hub. N. O. Myklestad, USA

3325. Wenk, E., Jr., Experimental determination of foundation modulus of elastically supported bars and rings, *Proc. Soc. exp. Stress Anal.* **10,** 2, 65–78, 1952.

Based on computed generalized relations among the natural frequencies of an elastically constrained structural member, the author uses measured natural frequencies to calculate the moduli of support stiffness for application to static stress analysis. Effective lengths of beams or widths of stiffened plates, virtual mass, etc., may be found in like manner. One unknown may be determined for each measured frequency. Test results for a ribbed cylinder and an elastically supported beam and a ring are shown to support the method.

The constrained member must be amenable to analytical determination of its general eigenvalues. The support's fundamental frequency must be much higher than the test frequencies so that the calculated moduli are reasonably constant and equal to the static values. For systems satisfying these conditions, the method appears useful and easier to apply than one based on static strain gaging. J. E. Corr, USA

3326. Eastwood, W., The factors which affect the natural frequency of foundations, and the effect of vibrations on the bearing power and settlement of foundations on sand, *Struct. Engr.* **31,** 3, 82–98, Mar. 1953.

Experiments using model foundations on dry and inundated sand to determine effect of load, base area, and shape of footing on natural frequency are described. The effect of a combination of vibration and static load on settlement and bearing power is investigated. R. N. Arnold, Scotland

3327. de Vries, G., Vibration techniques using additional masses (in French), *Rech. aéro.* no. 30, 47–49, Nov.-Dec. 1952.

Author presents method of calculating the effective mass of a vibrating system by observing the change in the natural frequency caused by adding known masses or elastic springs. Author claims that this method is more direct than others based on damping. A. Yorgiadis, USA

3328. Loring, S. J., Further results on the tuned test mass method of vibration testing, *Proc. Soc. exp. Stress Anal.* **10,** 2, 79–92, 1952.

Paper presents theoretical analysis of method of finding natural frequencies, mode shapes, and damping of large structure by means of freely vibrating test mass. An extensive discussion is given to case of multiple frequency modes (repeated roots). No experimental results are included. Reviewer sees no appreciable advantage over standard method using vibrator, and believes discussion of repeated root case to be of very limited practical importance. R. Plunkett, USA

Wave Motion, Impact

3329. Hufford, G. A., A note on wave propagation through an inhomogeneous medium, *J. appl. Phys.* **24,** 3, 268–271, Mar. 1953.

Author derives some corrections to Kirchhoff's formula and gives trial solutions in the case of the effective radius of the earth and the flat earth. But the corrections are in the form of integrals, which have yet to be evaluated. One cannot say, unfortunately, what is the order of magnitude of the proposed corrections.

Y. V. G. Acharya, Holland

3330. **Nomura, Y., and Takaku, K., On the propagation of elastic waves in an isotropic homogeneous sphere,** *J. phys. Soc. Japan* **7,** 2, 204–211, Mar./Apr. 1952.

Author determines coefficients of reflection for *P*- and *S*-waves successively reflected at spherical boundary and infinitesimal rigid center of elastic sphere. These lead, by complex function theory, to neat results containing the laws of geometrical optics.

W. Freiberger, Australia

3331. **Ursell, F., Mass transport in gravity waves,** *Proc. Camb. phil. Soc.* **49,** part 1, 145–150, Jan. 1953.

"A proof is given of the existence of a slow drift associated with the passing of gravity waves over the surface of a frictionless fluid when the wave motion is irrotational. The drift is in the direction of propagation and is greatest near the surface, decreasing steadily toward the bottom, where it may be negative if the fluid is of finite depth. The particle displacement due to a solitary wave has similar properties." Let $\varphi(x, y)$ and $\psi(x, y)$ be the velocity potential and stream function in a coordinate system giving steady motion. The author expresses x and y as Fourier series (integrals in the case of the solitary wave) in φ, and calculates $T(\psi_0)$, the time necessary for a particle on the streamline $\psi = \psi_0$ to move one wave length, as an expression in the Fourier coefficients. Suitable definition of the mass transport velocity and further computation lead to the result.

J. V. Wehausen, USA

3332. **Schmid, G., and Knapp, H., Ultrasonic transmission through porous bodies immersed in fluids** (in German), *Atti Conv. Internaz. Ultracust.* **1950,** 296–301, 1951.

Authors describe apparatus and discuss preliminary results of experiments carried out on alternating electric potentials developed across porous diaphragms immersed in electrolytes when ultrasonic waves are passing through the system. Phenomenon is related to Debye effect, but voltages developed are 10^3 times as great (of order of millivolts). Voltages developed have same frequency as applied ultrasonic wave. Voltage amplitudes are proportional to sound pressures and depend on diaphragm thickness.

Ultimate purpose of investigation is to develop a means of examining mechanisms attending passage of ultrasound through biological tissue.

P. Tamarkin, USA

3333. **Christensen, H., Harmonic generation and harmonic detection as a means of establishing useful signal power in the millimeter wave region,** *Tekn. Skr., Oslo,* Nr. 7N, 35 pp., 1953 = *Skipsmodelltankens Medd.* Nr. 9, Nov. 1951.

Using 10 cm and 3 cm sources, harmonic generation and harmonic detection are explored for the purpose of obtaining microwave radiation for spectroscopic application in the wave-length range from 1 cm to 1 mm. The program discussed in this paper was undertaken to examine various aspects of the combination of harmonic generation and harmonic mixing. With a fundamental wave length of 5–6 mm, a useful power level below 2 mm seems to be available. The crystal rectifiers appear as usual to be one of the limiting features in the low mm range. The work described is quite interesting; it needs to be carried much further.

R. Truell, USA

3334. **Thomson, W. T., Transmission of pressure waves in liquid filled tubes,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 927–933, 1952.

Propagation of pressure waves in a thin tube filled with liquid is investigated. The effects of inertia, stiffness, Poisson's ratio, and flexural waves in the tube are considered, and the results are reduced to nondimensional form to facilitate the study of variation of any parameter.

For any given frequency the study indicates that a finite number of modes are transmitted. Of these, only the lowest mode is transmitted with a velocity less than the characteristic value. The division of energy between the liquid and the tube walls is found to be of importance for the lowest mode. The effect of viscosity on the propagation is investigated by assuming the viscosity to be small and utilizing the velocity distributions of the inviscous cases. Numerical computations are carried out for the first three modes of a particular liquid-pipe system.

The paper adds to the work of Lamb, Fay, Jacobi, and others who have treated various phases of the problem.

From author's summary

3335. **Fleischhauer, E. T., and Dorsey, E. G., Jr., Static-dynamic load machine for high pressure,** *Trans. ASME* **75,** 381–383, April 1953.

Machine is described for systematic study of fixed-point fluid seals, moving fluid seals, and impact loads. Strain gage and camera equipment permit analysis of allied physical phenomena relating to high pressure and shock loading in liquids and gases. Machine is capable of pressures to 50,000 psi, impact to 10,000 ft-lb, and velocities to 90 fps on 2-in. diam piston. Large cylinder pressurized by commercial inert gas cylinder actuates piston in small cylinder. Limited tests at low pressures indicate good agreement with predicted performance. C. R. Freberg, USA

3336. **Miche, R., Principal statistical criteria characterizing real irregular sea waves and the methods of reproducing these waves in the laboratory** (in French), *Rev. gén. Hyd.* no. 69, 115–124, May-June 1952.

Paper consists of two parts. The main part is theoretical and tells how one can describe the motion of an "established and regular" sea wave. From harmonic analysis it is known that there are at least 20 to 25 frequencies represented in such a wave, but author shows that it is possible to describe the frequency and amplitude distributions by Gaussian distributions, and the wave is then characterized by three parameters, namely, the average amplitude, the average period, and the root-mean-square frequency. The calculated and measured probability distribution of both frequencies and amplitudes are in excellent agreement.

In the second part, author describes two methods of producing laboratory waves with the characteristics of real "established and regular" waves. The first method is by superposing mechanically periodic waves of amplitude and frequency distributions corresponding to the three parameters mentioned above. The second method consists in propelling the water by underwater fans. At some distance from the fans, the movement will resemble real ocean waves.

Both methods have been used at the Central Hydraulic Laboratory of France and both seem to be satisfactory. The waves produced act like real waves as far as transport of solid materials, multiple reflections in a harbor, and water movement in a harbor are concerned.

D. ter Haar, Scotland

3337. **Kirschmer, O., Waves, wind forces, and harbors** (in German), *Bauingenieur* **28,** 2, 45–52, Feb. 1953.

Author reviews the actual knowledge on surface waves and their action on dikes and harbors. Therefore, Gerstner's and Stokes' theories of wave motion are summarized; knowledge on interference, reflection, and energy of waves is also recalled. Paper closes with references to modern American and German research on prediction of waves and model studies.

G. Supino, Italy

Elasticity Theory

(See also Rev. 3293)

3338. Kammerer, A., Hooke's law and the limits of the extent of true elasticity (in French), *Metallurgia Ital.* **45**, 2, 41–46, Feb. 1953.

Paper considers the derivation of stress-strain equations for an (initially) homogeneous, isotropic, elastic medium, these equations being given correct to second-order terms in the strains. Attention is given to effects due to these second-order terms, and also to effects due to the presence of internal friction. One result derived is that there is a situation that is described as a "fatigue limit." The correlation of such a situation with the physical situation in which there is fatigue of the material is, in reviewer's opinion, incorrect because it is not the case that material fatigue is explicable on the basis of a continuous hypothesis.

H. G. Hopkins, USA

3339. Dimitrov, N., The influence line of the second-order theory and some practical formulas (in German), *Bauingenieur* **28**, 1, 19–22, Jan. 1953.

Approximate formulas are given for moments and deflections in beams under combined transverse and end loads. They are obtained as a first approximation solution of the integrodifferential equation for the bending moment. Author states that the basic results were derived previously from more elementary considerations by Moersch and Dischinger, but he seems unaware of similar American work [e.g., Roark, "Formulas for stress and strain," McGraw-Hill Book Co., Inc., New York, 1943, p. 135]. Paper also shows how the formulas for the deflections may be used to find approximate values for the buckling loads in statically indeterminate configurations. The style of the report is clumsy, and reviewer feels that unnecessarily heavy mathematical arguments are used for an essentially elementary problem.

J. H. Argyris, England

3340. Richter, H., On the elasticity theory of finite displacements (in German), *Math. Nachr.* **8**, 65–73, 1952.

3341. Milne-Thomson, L. M., Plane elastic problems, Conferencias de Matematica, Vol. III, Instituto de Matemáticas "Jorge Juan," Madrid, 1952, 27 pp. = *Rev. Mat. Hisp.-Amer.* (4) **9**, 110–123, 141–153, 1949.

3342. Paschoud, J., Simplified calculation of hollow bodies of revolution subjected to deformations conserving the axial symmetry (in French), *Bull. tech. Suisse Rom.* **79**, 7, 81–88, Apr. 1953.

The author arrives at a linear fourth-order differential equation for the radial displacement of a shell of revolution. The derivation of this equation neglects lateral contraction, thus the Poisson ratio. A rigorous treatment (to be published by the author) will show that in the obtained differential equation, the terms with a factor $\sin \varphi$ are cancelled, where φ is the angle between the tangent to the meridian and the axes of revolution.

Only those cases are considered where the coefficients of the afore-mentioned differential equation may be taken constant. Special formulas for the statically indeterminate quantities at the ends of a short (in axial direction) shell are given.

The method followed delivers results within 10% accuracy. It is applied to the calculation of forces and moments in the spherical end-shell of a cylindrical container subjected to internal pressure, and indeed, in a quick way, a reliable result is obtained.

J. P. Benthem, Holland

3343. Chu, C., The effect of initial twist on the torsional rigidity of thin prismatical bars and tubular members, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 265–269, 1952.

Author has developed the general solutions for the stiffness and stresses due to torsion in thin strips and in thin-walled tubes when the member has initial twist. The physical mechanism of the torsional stiffness follows that given by Timoshenko in "Strength of materials," vol. II, pp. 298–304. The increased stiffness is due to the torsional moment associated with the normal stresses induced in the cross section by differential straining of the longitudinal fibers. These effects are of practical significance in the stress and vibration analysis of propeller blades. Comparisons are made between theory and experiment for the torsion of the thin strip. In an appendix, second-order effects are considered, and a maximum shear theory strength analysis is given, the derivation of which is somewhat obscure.

J. E. Duberg, USA

3344. Das, S. C., Note on the elastic distortion of a cylindrical hole by tangential tractions on the inner boundary, *Quart. appl. Math.* **11**, 1, 124–127, Apr. 1953.

Using infinite series, two problems concerned with a circular cylindrical hole in plate of finite thickness are solved: (1) Localized tangential traction acting over part of boundary of hole, faces of plate being free; (2) uniform tangential traction acting over hole, one face of plate being fixed and the other free. Solution in integral form is obtained for localized tangential traction acting over narrow band of boundary of infinitely long cylindrical hole in infinite solid.

A. E. Green, England

Experimental Stress Analysis

3345. Letner, H. R., Application of optical interference to the study of residual surface stresses, *Proc. Soc. exp. Stress Anal.* **10**, 2, 23–36, 1952.

An optical interferometer method useful for simultaneous determination of biaxial stresses in small specimens is presented. Previous work in the determination of uniaxial stresses is presented in the bibliography, as well as other work in optical methods. The author extends such methods into two-dimensional fields with a method that yields vertical magnifications of 4300 to 86,000.

Successive removal of stressed surfaces by chemical etching, and photographs of interference patterns give a complete pattern of stresses at exposed surfaces which may be 0.0001 in. apart.

Reviewer believes that although neither the theory nor the method is new in principle, the paper describes the apparatus and procedure in such detail as to promote the use of the method described.

H. M. Gillerman, USA

3346. Parsons, K. A., Photoelastic studies of quenched cylinders and spheres, *J. appl. Phys.* **24**, 4, 469–472, Apr. 1953.

Residual stresses produced by quenching glass cylinders and spheres are determined by means of photoelasticity, using a Babinet compensator. The photoelastic results are compared with the results from the mathematical theory which was developed by R. C. O'Rourke and A. W. Saenz. Experimental and theoretical results agree qualitatively, although the quantitative comparison shows that the theory needs improvement. Author states that the lack of agreement is probably due to the effect of plastic flow and the effect of temperature on the physical constants, which were neglected.

W. B. Stiles, USA

3347. **Jessop, H. T., The scope and limitations of the photoelastic method of stress analysis,** *J. roy. aero. Soc.* **57,** 507, 125–140, Mar. 1953.

This paper is a summary of photoelastic techniques used at present for two- and three-dimensional states of stress. Fringe patterns of models made for industrial research are presented as illustrative examples. In the discussion, the author lists materials available in England for photoelastic analysis; Marco resin, introduced recently for making three-dimensional cast models, has been included. E. O. Stitz, USA

3348. **Leven, M. M., and Frocht, M. M., Photoelastic determination of stresses on the surface of poppet valves,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 317–324, 1952.

Using relatively large Fosterite models and the method of stress freezing and slicing, the stresses on the surface of poppet valves were investigated for three basic types of head designs, namely, flat, dished, and umbrella heads.

The results obtained from Fosterite models are then compared with results obtained from previous tests which were made using small Bakelite models, approximately one third the size of the Fosterite models. The results are further compared with the findings from two-dimensional tests using flat models of celluloid and Bakelite.

Three conclusions were reached: (1) The tests with Fosterite show that for the same weight of valve head the umbrella valve will have smaller stresses than the dished valve, which is, in turn, superior to the flat valve. (2) In general, the results from small Bakelite models substantiate the above conclusion. (3) Two-dimensional models yield vastly greater stresses, having a different distribution than exists in the three-dimensional valves, and cannot be used as a substitute for three-dimensional studies. The two-dimensional tests are not consistent in indicating the relative merits of the different designs or the location of the maximum stresses.

From authors' summary by C. E. Taylor, USA

3349. **Brock, J. S., and Eder, J. P., Stresses in a photoelastic model of a bottom longitudinal connection at a bulkhead in navy oilers,** *David W. Taylor Mod. Basin Rep.* 851, 5 pp., 8 figs., Feb. 1953.

A photoelastic model of the bottom longitudinal connection at the bulkhead in navy oilers was made and tested at the David Taylor Model Basin to determine the elastic stress distribution and the stress concentrations in the connection. This report gives the results of this test and recommends further tests to determine cause of failure in service.

From authors' summary by T. Grow, USA

3350. **Hawkes, J. M., The measurement of stresses in framed structures,** *Civ. Engng., Lond.* **47, 48,** 554, 555, 556, 557, 558, 559, 560, 561; 644–646, 752–754, 842–844, 933–936, 1029–1031, 75–77, 166–168, 261–263; Aug., Sept., Oct., Nov., Dec. 1952, Jan., Feb., Mar. 1953.

This series of eight articles summarizes the techniques of static and dynamic strain measurements using commercially available transducers. The instruments described are resistance, acoustic, capacitance, and inductance strain gages; scratch gages, Stress-coat, as well as the Lamb, Huggenberger, Johanssen, and Ewing extensometers.

Elementary techniques for use are outlined, as well as some brief data on resolution, sensitivity, and response characteristics.

G. S. Cherniak, USA

3351. **Yamamoto, M., Stress concentration produced by pin joint of a flat bar,** *Mem. Fac. Technol., Tokyo Metrop. Univ.* no. 2, 62–72, 1952.

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 3312, 3343)

3352. **Wright, W., Stresses in curved beams—a tabular method of solution based on Winkler's theory,** *J. appl. Mech.* 20, 138–139, Mar. 1953.

Superposition of a direct compressive load with any desired bending moment is used to keep the length of the centroidal beam fiber constant. Usual Winkler-Bach relationships are used to obtain the stresses under the two loads. Method uses Simpson rule for evaluation of integrals and is easily applied to any shaped area. Stress due to bending alone is then obtained by subtraction of the stress due to direct axial load. Primary result of this paper is the speed and ease of solution for complex areas. Use of a "modified area" is avoided and the very troublesome subtraction of nearly equal quantities is unnecessary. Accuracy of the method is high, being better than 1% for simple areas. Reviewer believes this paper could have been written more clearly, since the method is a very neat and direct one and should be of considerable use.

T. A. Hunter, USA

3353. **Morrison, T. G., Rapid computation of flexural constants,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 170, 10 pp., Feb. 1953.

Systematic procedure is presented for computing stiffness, carry-over factors, and fixed-end moments for beams of variable cross section. It is shown that a minimum of computation is required if numerical integrations along the beam length of the reciprocal of the moment of inertia times suitable functions are used as a basis for analysis. In a typical case, author shows that numerical integration with a beam approximated by four segments of constant moment of inertia gives errors of about 5%. Using eight segments gives errors of about 2%. Two numerical examples are presented. S. Levy, USA

3354. **Klöppel, K., and Lie, K. H., Stresses in laterally loaded beam flanges** (in German), *Stahlbau* **21,** 11, 201–206, Nov. 1952.

Problem considered is that of finding additional local stresses resulting from introducing transverse loads into "I" or "tee" beams through the flanges rather than the web. For example, such loading is encountered when the beam is used as track for a crane. Flange is considered as infinite strip with one edge free, one edge fixed. Loadings treated are a single concentrated load at mid-width and a uniform line load across width. Problem is analyzed by conventional small-deflection plate theory, using principle of minimum potential energy. Three distinct solutions are carried out for each loading condition. Since these solutions each possess different defects with respect to the boundary conditions at the free edge, the calculated stresses show appreciable differences. The usual difficulties are encountered with the slow convergence of the series representing the stresses. Because the functions employed are not orthogonal, coefficients must be evaluated by solving simultaneous equations, and it is impractical to employ a very large number of terms.

An experimental study of the problem was also made using an electric strain gage. An I-section was used for the tests and strains were measured in both upper (loaded) and lower flanges. Algebraic sum of like stress components at corresponding points of upper and lower flanges is taken to represent local stresses due

to transverse loading of upper flange. These results are exhibited graphically. Comparison with the best of the analytic solutions shows good qualitative agreement for the concentrated load case. In the experiments, the assumed condition of a uniform line load was not duplicated, since a relatively rigid die was used to apply the load. Accordingly, the agreement with the analytic results is rather poor for this case. R. E. Newton, USA

3355. Conroy, M. F., Plastic-rigid analysis of long beams under transverse impact loading, *J. appl. Mech.* **19,** 4, 465–470, Dec. 1952.

Author applies plastic-rigid analysis (neglect elastic strains so that elastic material can be considered rigid) to case of plastic flow at constant yield limit to obtain analytical expressions for bending moment, shear force, curvature, and deflection distributions along the beam for any given impact velocity. Author encounters difficulties in attempting to apply the procedure to a work-hardening material, obtaining probable forms of the solutions but no analytical results. B. E. Gatewood, USA

3356. Csonka, P., The position of the neutral axis in oblique bending (in Hungarian), *Mélyépitéstudományi Szemle* **1,** 7, p. 405, 4 figs., July 1951.

A method has been developed by means of which the neutral axis may be determined much more easily, i.e., by eliminating the notion of the central ellipse. It is assumed that the principal axes and their moments of inertia are known, and that lines of intersection of the plane of the bending force couple acting on the cross section of the bar are given. Under these circumstances, the equation and the angle of elevation of the neutral axis are determined. The obtained results make it possible to establish the neutral axis by delineating.

Courtesy of Hungarian Technical Abstracts

3357. Cowan, H. J., Torsion of a rectangular elastic isotropic beam reinforced with rectangular helices of another material, *Appl. sci. Res.* (*A*) **3,** 5, 344–348, 1952.

The problem of the torsion of a composite rectangular beam with helical bars has an important application in the theory of reinforced concrete. An approximate solution is derived by an extension of Saint Venant's theory, and numerical values of the principal functions are given. Agreement with experimental data is recorded. From author's summary

3358. Tekinalp, B., Generalisation of the conjugate beam method to space rods, *Bull. tech. Univ. Istanbul* **4,** 1, 29–36, 1951.

A conjugate beam method for the solution of the displacement of space rods with different end conditions.

C. B. Matthews, USA

3359. Onat, E. T., and Shield, R. T., Remarks on combined bending and twisting of thin tubes in the plastic range, ASME Nat. Conf. appl. Mech., Minneapolis, Minn., June 1953. Paper no. 53—APM-18, 4 pp.

The influence of the loading program on the agreement between the predictions of the Hencky and the Prandtl-Reuss stress-strain relations for a perfectly plastic material is investigated in the case of the combined bending and twisting of thin-walled tubes. The agreement in the values of the bending and twisting moments is found to vary considerably with the particular loading program chosen. The analysis is extended to tubes composed of a work-hardening material. The bending and twisting moments are obtained numerically, using the incremental approach for a square tube which is bent and then twisted. Owing to the large amount of labor involved in this solution, an approximate method using the concept of a "composite" beam is developed, and good agreement in the results is found with those obtained from the incremental solution.

From authors' summary by C. B. Biezeno, Holland

3360. Ranov, T., and Park, F. R., On the maximum numerical value of the tangential stress in thick-walled cylinders, *J. appl. Mech.* **20,** 1, 134–137, Mar. 1953.

An elastic thick-walled cylinder is subject to internal and external pressures. Authors examine Lamé's equations and show that, for certain values of the pressure ratio, the numerically largest circumferential stress may occur at the outer radius. A chart is supplied to locate the numerically largest circumferential stress for any given pressure ratios and cylinder dimensions.

M. C. Steele, USA

Plates, Disks, Shells, Membranes

(See also Revs. 3342, 3344, 3375, 3572)

3361. Livesley, R. K., Some notes on the mathematical theory of a loaded elastic plate resting on an elastic foundation, *Quart. J. Mech. appl. Math.* **6,** part 1, 32–44, Mar. 1953.

Employing Winkler's hypothesis for the reaction pressure of a foundation to an elastic plate, the author derives the deflection of a semi-infinite plate and of an infinite quadrant plate under static loads for the condition of simply supported edges. These solutions are obtained by superposition of the symmetric and antisymmetric cases of an infinite plate, and the results are shown by Fourier integrals. Another problem shows the deflection expression of a semi-infinite plate with its free edge loaded by given distributions of bending-edge moment and of edge-shearing reactions similar to the original problem of Westergaard for a single-edge point load.

The final problem treats the infinite plate under the action of a uniformly traveling load. In the case of a concentrated load, the deflection at the moving load point is expressible in terms of tabulated elliptic integrals and the known result of Hertz of this deflection in the static case. The corresponding bending moment under the point load becomes infinite; however, if this singularity is reduced to rational results by the usual methods of thick-plate theory, the author finds an upper bound for the excess of this moment under the dynamic load over that for the same static load. D. L. Holl, USA

3362. Mikhlin, S. G., Some theorems of the theory of operators and their application in the theory of elastic shells (in Russian), *Doklady Akad. Nauk SSSR* (*N.S.*) **84,** 5, 909–912, June 1952.

After establishing some theorems concerning the extent and the spectrum of self-adjoint operators in Hilbert space, author proceeds to show that the difference of stresses in shells of fixed thickness and stresses in an associated plate can be made as small as desired, under certain conditions, independent of the type of loading. G. Herrmann, USA

3363. Layrangues, Statics of thin shells by the method of vector analysis (in French), *Ann. Ponts. Chauss.* **123,** 1, 69–105, Jan.-Feb. 1953.

Author investigates the extensional solutions for loaded thin shells. The equilibrium equations are derived by application of vector calculus. The coefficients of the unknowns and their derivatives in these equations are dependent on the geometrical properties of the middle surface of the shell. For different classes of

surfaces the equations are investigated and solved. Some special cases are extensively studied; e.g., the cone and the surfaces $z = xy/a$, $(x^2 + y^2)/a^2 - z^2/b^2 = 1$ (x, y, z, Cartesian coordinates).

The disturbance, which arises when the boundary conditions are not suitable for the extensional solutions, is not considered. Author emphasizes the importance of the extensional solutions for different classes of buildings. J. W. Cohen, Holland

3364. Clark, R. A., and Reissner, E., A problem of finite bending of toroidal shells, *Quart. appl. Math.* **10,** 4, 321–334, Jan. 1953.

This paper deals with the deflections of an omega joint, the linear theory of which has been dealt with by the first-named author [AMR **4,** Rev. 2429]. Here the problem of the validity of the linear theory is discussed and corrections are obtained. The parameter $\mu \sim b^2/ah$ is critical in the equations and produces different solutions, depending on whether μ is of order one or large compared with unity. The latter case is of interest for practical applications, and corrections may be obtained in powers of $\mu^{2/3}\Omega$ where $\Omega \sim a/h^2$. Numerical results are given. It is shown that the deflection may be large compared with the wall thickness of the shell without the occurrence of nonlinear effects.
R. C. Knight, England

3365. Zizicas, G. A., Stability of thin elastic plates covering an arbitrary simply connected region and subject to any admissible boundary conditions, *J. appl. Mech.* **20,** 1, 23–29, Mar. 1953.

Author finds the critical loads and buckling modes for a plate subject to forces in the plane of the plate by using Bergman's method to solve the boundary-value problem. This method consists of obtaining complete sets of particular solutions of the partial-differential equation, the particular solutions being the real and imaginary parts of functions, expressed as infinite series, of two conjugate complex variables. A linear combination of particular solutions is then chosen so as to approximate the boundary conditions by the method of least squares.

The paper is a generalization to homogeneous anisotropic plates of work done by Krzywoblocki [AMR **1,** Rev. 1109] for homogeneous isotropic plates. Only the principles of the theory are presented. For further details, the reader is referred to the author's doctoral dissertation. Explicit examples are to be reported later. An extensive bibliography is given. R. A. Clark, USA

3366. Prescott, G. R., Rupture-disk design evaluation and bursting tests, *Trans. ASME* **75,** 3, 355–359, April 1953.

Design and operating problems for a specific type of rupture disk are treated. Although the detailed discussion applies to only one specific material and to one general disk design, the difficulties encountered are general in nature and must be considered in any treatment of rupture disks as installed to prevent dangerous overpressures in pressure vessels. It is shown that the range of rupture pressures cannot be accurately established without due consideration to machine tolerances, material physical properties variations, and operating temperature.

The notation used in Eqs. [1] and [2] is somewhat confusing. This could be eliminated if Eq. [1] were written as $P = 4st/d$, where P (instead of R) is the rupture pressure. Eqs. [1] and [2] would then be consistent. E. E. Sechler, USA

3367. Manson, S. S., Analysis of rotating disks of arbitrary contour and radial temperature distribution in the region of plastic deformation, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 569–577, 1952.

Using finite-difference methods and deformation theory of plasticity, method was developed for determining displacements and stress-and-strain distributions in rotating disks of arbitrary contour and radial temperature distribution subjected to either partial or total plasticity. Validity and practicality of method were demonstrated by performing calculations that led to predicted results in agreement with phenomena that had been investigated experimentally [AMR **1,** Rev. 1321; **4,** Rev. 4155; **6,** Revs. 1517, 1610]. Modifications to method for problems involving variable density or cycling conditions can be obtained from previous publications of author [AMR **1,** Rev. 423; **3,** Revs. 853, 1071].

Reviewer's experience with method has shown that, for more complicated problems (maximum stress and strain not occurring at center, e.g.), the trial-and-error calculations should be made for very small speed increments (order of 5%) above yield speed when a new contour and temperature distribution are attempted. Subsequently, effects of small changes in contour or temperature distribution can be investigated quite rapidly.
A. G. Holms, USA

3368. Belov, A. V., and Vasil'ev, P. I., Practical method for determining temperature (stresses) in a concrete slab during harmonic fluctuations of air temperature (in Russian), *Gidrotekh. Stroit.* no. 9, 19–26, Sept. 1952.

The paper presents the method of determining stresses in a concrete plate caused by harmonic fluctuation of temperature of air on one side of the plate, while the air temperature on the other side remains constant. The main part of the problem is the solution of the differential equation of heat flow for determination of plate temperatures. This solution is simplified by assumption for the temperature of an exponential expression of imaginary power, whose real part forms the required solution.

The corresponding temperature stresses are found by assumption of elastic conditions and of linearity of the cross section, while the ends of the plate remain either free or fixed, and the fixation may be either lengthwise or with regard to rotation.

The theory is further extended to allow for the effects of creep in concrete by the use of the so-called relaxation curve based on experiment. The latter represents the law of gradual reduction with time of a stress brought about by sudden application of strain. When the strain is induced gradually by temperature variation, each increment of stress is reduced in later times in accordance with the ordinates of the relaxation curve corresponding to the time elapsed, and the effects of separate stress increments are superimposed.

The application of the method is demonstrated on a specific example of a concrete plate subjected to daily and annual temperature variations. A. Hrennikoff, Canada

3369. Thomas, D. G. B., The autofrettage of thick tubes with free ends, *J. Mech. Phys. Solids* **1,** 2, 124–133, Jan. 1953.

Author uses Prandtl-Reuss equations of incremental plastic strain, Tresca's maximum shear stress yield condition, and the assumptions that tube is sufficiently long to make stresses and strains independent of axial coordinate, that ends of tube are not loaded but tube is free to expand axially (open-end condition), and that axial stress is intermediate principal stress. Three hyperbolic partial-differential equations, first given by Hill, are derived for radial displacement, axial stress, and axial strain as functions of radial coordinate r and position c of elastic-plastic boundary. Radial and circumferential stresses are statically determined in terms of the internal pressure. The equations are integrated numerically along their characteristics r = const, c = const by dividing the r-c plane into a rectangular mesh. Resulting numerical values of surface strains, axial stress, and internal pressure are

tabulated for various positions of the elastic-plastic boundary; tangential and radial stresses had been published previously by Hill. Comparison is made between stress and strain values as given by the incremental theory and the values found by various authors using Hencky's total-strain theory. The differences in axial stress and strain are shown to be much more significant than in corresponding comparisons for closed-end and plane-strain tubes, but small in the values of radial expansions.

W. Freiberger, Australia

Buckling Problems

(See also Rev. 3339)

3370. Newton, R. E., Experimental study of inelastic buckling of columns of varying section, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 625–629, 1952.

Author studied the title problem for hot-rolled mild steel, Alcoa 24S-T4 aluminum, and Dow T-1 magnesium. For each material he considered columns of constant cross section and two families of columns with varying rectangular cross sections. One family had constant depth of 0.5 in. and tapered linearly in width from 1 in. at the center to 0.5 in. at the ends. The other family was designed with constant width of 1 in. and linear taper in depth from 0.5 in. at the center to 0.4 in. at the ends. Thus the two families have approximately equal inertial moment distribution but widely different distributions of cross-sectional areas. Slenderness ratios were chosen from 35 to 110 for magnesium and aluminum and from 42 to 168 for steel, so that a substantial number of specimens failed in the inelastic range.

The experimental results were compared with a theoretical analysis based on Rayleigh's technique and the tangent modulus theory, as contrasted to previous results of D. Young [*J. appl. Mech.* **12**, 3, 165–169] which were calculated on the basis of the reduced modulus. The agreement for aluminum and in the elastic range for steel and magnesium is generally very good—the discrepancy being over-all less than 3%. Larger deviations appeared in the inelastic range for mild steel and magnesium but, as pointed out by the author, are only apparent and are due to neglecting the strain-hardening range in the assumed relations between tangent modulus and strain. Author concludes that his experimental results support the tangent modulus theory for columns of varying cross section with the possible exception of very short columns.

G. A. Zizicas, USA

3371. Wilder, T. W., III, Brooks, W. A., Jr., and Mathauser, E. E., The effect of initial curvature on the strength of an inelastic column, *NACA TN* 2872, 17 pp., Jan. 1953.

The reduction in column strength due to initial curvature is determined theoretically for a pin-ended idealized inelastic H-section column. Equations relating load and lateral deflection are obtained which permit a systematic variation in the parameters representing the stress-strain properties, column proportions, and initial curvature of the column. The results, presented graphically, show the effect of various combinations of these parameters on column strength.

From authors' summary by T. H. Lin, USA

3372. Csonka, P., On the theory of plastic buckling (in German), *Acta Techn. Hung., Budapest* **5**, 1, 47–55, 1952.

Author derives the relationship between the compressive force and the lateral deflection at midheight for an axially loaded, prismatic bar. The cross section is assumed to be composed of two very thin flanges, and the bending occurs in a plane normal to the flanges. The stress-strain curve for the material is described by two straight lines. Plastic set is ignored, i.e., a unique value of strain is assumed to exist for each value of stress.

The governing differential equations are solved to yield the curved equilibrium configuration for each value of load between the critical load based on the tangent modulus and that on the double modulus.

This paper is thus an extension of Shanley's theory to this case of distributed flexibility. The results are compared with the model discussed by Shanley, which was a perfectly rigid bar with the exception of a small portion at midheight.

W. J. Austin, USA

3373. Pflüger, A., On the plastic buckling of straight rods (in German), *Ing.-Arch.* **20**, 5, 291–301, 1952.

Author treats the plastic buckling of a uniform beam of initial eccentricity with a doubly symmetric cross section, using the Shanley concept of buckling. The cases of rectangular and I-cross sections are solved in detail. The paper is a neat presentation, but no reference is made to somewhat similar results by Dubert and Wilder [AMR **4**, Rev. 1521] and Cicala [AMR 4, Rev. 1522].

H. J. Weiss, USA

3374. Kappus, R., Centric and eccentric torsional buckling of bars of thin-walled open cross section (in German), *Stahlbau* **22**, 1, 6–12, Jan. 1953.

Paper is written to acquaint design engineers with the established results of theories presented elsewhere and does not contain new material except as stated hereafter. Results are given of 54 tests on centrically loaded Dural angles $1^1/_4$ in. by $1^1/_4$ in., having a range of flange thickness from 0.024 to 0.08 in., and 9 to 54 in. long. An approximate formula is presented, without derivation, for the effect of the deflection of an eccentrically loaded bar on the buckling load. It is claimed that the results of this formula agree with results obtained for this case by Chwalla.

H. H. Bleich, USA

3375. Floor, W. K. G., and Burgerhout, T. J., Evaluation of the theory on the post-buckling behaviour of stiffened, flat, rectangular plates subjected to shear and normal loads, *Nat. LuchtLab. Amsterdam Rep.* S.370, 13 pp., 6 tables, 20 figs., 1951.

Paper reports additional numerical calculations for Koiter's theory of the postbuckling behavior of stiffened flat plates [*Nat. LuchtLab. Amsterdam Rap.* S.295] for the purpose of its convenient application to practical problems in the aircraft industry. Results are represented in a series of diagrams each showing the relations among strain ratios ϵ_1/ϵ^*, ϵ_2/ϵ^*, compressive stress ratios σ_1/σ^*, σ_2/σ^*, and stiffness ratio $\tau/\gamma G$ for a specific value of shearing stress ratio τ/σ^*, where ϵ^* and σ^* are, respectively, the strain and the stress at which an infinitely long flat plate with hinged edges buckles under a pure longitudinal compression. Given a value of τ/σ^* and two relations among the parameters from conditions of equilibrium, a point on the diagram is located, and values of the remaining five parameters can be immediately read off. Four numerical examples are given of the determination of the average stresses and strains or the required stiffener cross sections of specified stiffened plates subjected to specified compressive and shear loads. Proposals are made for a number of additional investigations intended to increase the range of applications and the usefulness of the diagrams.

Several earlier papers on experimental verifications of Koiter's theory have been reviewed in AMR **1**, Rev. 1196; **2**, Revs. 602, 995; **5**, Rev. 73.

G. C. K. Yeh, USA

3376. Trösch, A., Stability problems in rotating rods and shafts (in German), *ETH Prom.* no. 2118, 21 pp., 1952.

See AMR **6**, Rev. 1208.

Joints and Joining Methods

(See also Rev. 3364)

3377. **Holm, Else, and Holm, R., The fundamentals of the welding of electric contacts under heavy current conditions,** *ASTM Bull.* no. 188, 39–44, Feb. 1953.

The problem of welding or sticking of electrical contacts is present in many types of circuit making and breaking equipment. When the contacts weld or stick, a solid metal joint is formed between the contact members which may be stronger than the opening force available in the device. Under heavy current conditions, which alone are considered in this paper, the weld is the result of melting or of considerable softening of the metal in the contact. It is of practical interest to possess a theory for the computation of the weld strength to be expected. This paper provides fundamentals for such a theory.

A method of calculating the strength of a weld as a function of the maximum current and the hardness of the annealed metal is developed for an "ideal" case with simplified conditions. The most important of these conditions is the assumption that the metal does not oxidize.

The application of the theory is facilitated by diagrams. Experiments with silver confirm the theory. Measurements with nickel, steel, molybdenum, and tungsten exemplify what proportion of the "ideal" weld strength may be expected in metals which do oxidize. From authors' summary

3378. **Bennett, R. W., An evaluation of the properties of weld metal for fabricating heat exchangers and vessels for low-temperature service,** ASME Ann. Meet., New York, Dec. 1952. Paper no. 52—A-146, 10 pp., 7 figs.

Evaluation is based upon a notch toughness (keyhole Charpy impact) of at least 15 ft-lb for three specimens tested at the minimum service temperature to which the vessel is designed. A comparison of nine brands of AWS Class E-8016 electrodes and two E-7020 electrodes indicated only three of the E-8016 brands suitable for −150 F service. Transition temperature curves indicated E-7020 and E-6020 electrodes suitable for service to −50 F. Author observed that a coarse-grain dendritic weld metal generally had lower notch toughness, and that the "as-deposited" structure of the final pass is located where it is most apt to initiate failure. Author suggested the condition is easily remedied by adding an extra weld pass, then grinding the weld flush so that the outer weld surfaces would have a fine-grained structure. Grinding would also eliminate the stress raised at the intersection of the toe of the weld and the base metal.

C. E. Hartbower, USA

Structures

(See also Revs. 3350, 3375, 3596)

3379. **Guerrin, A., Reinforced concrete. I. General properties. Experimental techniques [Traité de béton armé. I. Généralitiés. Propriétés générales. Mécanique expérimentale du béton armé],** Paris, Dunod, 1952, 314 pp.

Part one gives a historical review of development of reinforced concrete; discusses properties of steel, sand, gravel, mixing water, and cement. Also discusses bond, density, deformation, resistance to fire, permeability, and resistance to corrosive media. Part one ends with descriptions of the general arrangements of many reinforced-concrete members.

Part two treats experimental mechanics of deformation, of cracking, and of failure of loaded reinforced concrete. For plain concrete, the findings of many expert researchers are discussed in relation to compression, tension, flexure, shear, torsion, shear and compression, shear and tension, shear and flexure, and ductility of concrete. For reinforced concrete are discussed compression, tension, shear, and flexural members. The effects of shrinkage, plastic flow, and repeated loads are also discussed. The ultimate theory as related to reinforced concrete is discussed.

Throughout the book only enough theory is given to allow the reader to understand the meaning of the experimental results.

Reviewer believes book is a good, orderly presentation of pertinent experimental information on concrete and reinforced concrete. Because of the tremendous amount of experimental information available, it was necessary to be selective and to abbreviate discussions. R. B. B. Moorman, USA

3380. **Guerrin, A., Reinforced concrete. II. Theory [Traité dé béton armé. II. Le calcul du béton armé],** Paris, Dunod, 1952, 300 pp.

After emphasizing that calculations are means of aiding judgment in design, the author presents much material that may be used for such aid. Rather complete set of expressions for computing stresses in members is given, such as for bond, shear, compression, tension, bending, and bending and direct stress. Rollers, brackets, deep beams, slabs of various shapes, and sections of unusual shapes are treated quite fully. Torsion, punching shear, unsymmetrical bending, and shrinkage are also discussed. Both elastic theory and ultimate theory are presented. Charts and tables are given to expedite computations.

Reviewer believes presentation to be quite complete and is pleased to note the graphical method for analyzing columns subjected to bending used here. Material covered relates to detail analysis and design. R. B. B. Moorman, USA

3381. **Falkenheiner, H., Systematic analysis of redundant elastic structures by means of matrix calculus,** *J. aero. Sci.* **20,** 4, 293–294, Apr. 1953.

Author discusses use of matrix notation in analysis of redundant elastic structures. In particular, he compares expressions and equations given by Langefors [AMR **5,** Rev. 3388] with corresponding statements in author's earlier papers [AMR **4,** Rev. 1541; **5,** Rev. 2956] and notes their equivalence.

R. W. Traill-Nash, Australia

3382. **Heyman, J., and Nachbar, W., Approximate methods in the limit design of structures,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 551–560, 1952.

Starting from the principles of the statically admissible and kinematically sufficient multipliers, established by Greenberg and Prager, the collapse of plane frames under concentrated loads is treated by approximate methods to obtain upper and lower bounds on the collapse factor. The techniques are extended to include cases of distributed loading.

From authors' summary by C. C. Wan, USA

3383. **Onat, E. T., and Prager, W., Limit analysis of arches,** *J. Mech. Phys. Solids* **1,** 2, 77–89, Jan. 1953.

It is well known that axial forces in frames and other continuous structures lower the plastic collapse load. The present paper is the first systematic treatment of the effects of axial forces on both the kinematics and the statics of the collapse state, taking account of the fundamental theorems of limit analysis due to Drucker, Prager, and Greenberg. However, geometry changes under load are neglected, so that questions of stability require separate investigation. In the circular-arch examples treated in

the paper, the axial forces did not appreciably affect the collapse mechanism, but the collapse load was lowered by about 13% (symmetrical loading) and by about 10% (unsymmetrical loading). P. S. Symonds, USA

3384. Wilder, T. W., III, An analysis of statically indeterminate trusses having members stressed beyond the proportional limit, *NACA TN* 2886, 13 pp., Feb. 1953.

An application of the principle of minimum complementary energy to statically indeterminate trusses stressed beyond the proportional limit is given. The theory is based on typical stress-strain curves for aluminum alloys. The nonlinear simultaneous equations that occur in a problem are solved by a process of successive corrections, starting with the elastic solution—comparable to an elastic perturbation technique.

The solution for a truss with two redundants is given. The scheme has difficulties of oscillatory divergence.

E. D'Appolonia, USA

3385. Banerjee, S. P., Influence lines for continuous girders, *Civ. Engng. Lond.* **48,** 560, 149–151, Feb. 1953.

Author presents method of obtaining influence lines for bending moments, shears, and reactions in continuous beams using Hardy Cross procedure of moment distribution. Three-span beam is solved in detail for illustration. Method may be extended to include variable moment of inertia and settlement of supports. Chief advantages claimed for the method are its simplicity and accuracy. W. E. Black, USA

3386. Grams, R., Method of angles of rotation for frames with curved cross girders (in German), *Beton u. Stahlbeton.* **47,** 2, 30–35, Feb. 1952.

A method is presented for solving plane rigid-frame structures which include curved beam members. Author sets up the equations for the curved as well as the straight members in terms of their unknown end rotations and translations. The set of simultaneous equilibrium equations is then reduced to a tabular form in terms of these unknowns. No new fundamental concepts are presented, but a technique of solution is offered. An example is worked out for a three-bay frame. J. M. English, USA

3387. Busemann, R., Analysis of buckling and bending of composite beams by means of the "creep-fiber method" (in German), *Stahlbau* **22,** 2, 25–29, Feb. 1953.

This paper discusses the application to several problems of a method that has been presented in two earlier papers by the author. See *Bauingenieur* **25,** p. 418, 1950, and *Stahlbau* **20,** p. 105, 1951. This method predicts the effect of creep in composite beams on the stresses and general behavior of such beams. The problems considered are: (1) Redistribution of stress in statically determinate beams; (2) the same for statically indeterminate beams; (3) beam with constant longitudinal compressive force. This last problem is the principal subject of the present paper.

M. P. White, USA

3388. Bergström, S. G., On the vertical stability of bridge arches (in Swedish), Thesis, Royal Inst. Technol., Stockholm, 184 pp., 1951.

In this paper, stability of bridge arches with respect to deformations in their own plane is studied. Main emphasis is placed upon built-in arches with no joint, and arches with two joints. Paper is divided into three parts: (1) Buckling of the arch in its own plane with a detailed account of previous work in this field, establishment of the differential equations of the problem, methods of solution with due consideration of practical usefulness, and numerical examples compared with experiments. (2) Calculation of additional bending moments due to elastic deformations, with demonstrations of how these moments may be found from knowledge of the eigenvalues and eigenfunctions from the first part of the paper. (3) Discussion of plastic deformations and the possibilitity of taking their influence into account. Throughout the paper, emphasis is placed upon giving approximate procedures suited for practical purposes where mathematically rigorous solutions would involve too complicated calculations.

To the reviewer the paper seems to be a valuable contribution. It should be stressed that the paper has been published as *Meddelanden* no. 19, 1951, Statens Kommitte för Byggnadsforskning, Stockholm, and that this edition contains a discussion by A. Aas-Jackobsen, L. Östlund, and F. K. G. Odqvist.

L. N. Persen, Norway

3389. Vogel, R., Preferable cross sections of deep bridge beams (in German), *Stahlbau* **22,** 2, 45–47, Feb. 1953.

Paper deals with double-symmetrical I-beams of height h. Flanges have constant width b but variable thickness over beam length. Thickness of web plate is expressed as an empirical function of h. After some approximations, author gets maximum flange thickness $t = t(W, h, b/h)$, where W is flexural rigidity required. As a measure of the decreasing flange thickness toward beam ends, a block factor χ is introduced. If $t = \text{const}$, $\chi = 1$. Further, a mean cross section F_m is introduced. $F_m l$ gives total metal volume if l is beam length. Author expresses $F_m = F_m(W, h, b/h, \chi, t^*)$, where t^* is flange thickness at beam ends. This expression differentiated once by h and set equal to zero gives an equation of sixth degree in h. The only usable root h_{opt}, used in the expression for F_m, gives the most favorable mean cross section. Numerical solution is necessary.

For effective use of given formulas, experience is required concerning suitable values of χ, t^*, and b/h, and of a suitable expression for $t_{st}(h)$. h_{opt} is slightly influenced by variations of b/h, but markedly influenced by variations of χ. Total beam weight is nearly independent of variations in χ and constant for $\chi > 0.8$. Method described is usable for beams of other shapes.

E. Steneroth, Sweden

3390. Stamm, C., Failure of bridge structures and its causes (in German), Zürich, Verlag Leeman; Mitt. Inst. Baustatik, ETH, no. 24, 99 pp., 1952. Fr. 12.50.

Using early and contemporary periodical literature concerning failures of various large-span steel bridges, author discusses the causes of these failures and tries to establish the necessary means of preventing them. As the engineering failures of large-span bridges are too high a price for progress in building, author thinks this book can be recommended to all bridge engineers, who will profit from it. J. B. Gabrys, USA

3391. Panchaud, F., Secondary stresses in statically indeterminate structures of prestressed concrete (in French), *Bull. tech. Suisse Rom.* **79,** 6, 65–75, Mar. 1953.

The selection of proper prestressing force and eccentricity in a statically indeterminate member is complicated by the fact that the prestressing affects the supporting forces, thus causing "secondary" moments in the structure. Author presents a method for shortening the necessary trial-and-error procedure.

From an incorrectly stated equation representing the "condition of continuity," a correct equation (resembling the well-known theorem of three moments) is derived, which expresses the secondary support moments in terms of the magnitude of the prestress forces and the variation in their eccentricity. Considering in

succession beam on three supports, beam on four supports, fixed portal frame, and beam with fixed ends, author then derives expressions for the secondary moments. The effect of variation in eccentricity of prestress force along a given span is expressed in terms of a dimensionless quantity μ and the maximum eccentricity. Values of μ for several common cases are derived.

Expressions for prestress force necessary to avoid tension under full load are derived for each of above cases. These are somewhat approximate in that they include a guess as to location of critical section. However, the calculated prestress force is only a first approximation, since top and bottom fiber stresses due to the various loading conditions must still be checked. The aforementioned equations for the secondary moments enable this to be done rapidly.

Due to an inaccurate interpretation of some of the equations the author develops, he states incorrectly that secondary moments at midspan of a beam will usually increase the maximum compression at the top by 15–20% and will not affect the stress at the bottom.

Reviewer believes that author's method should prove useful for the cases discussed. Although this method is general in application, for more complicated cases reviewer prefers an extension of the method of Parme and Paris [AMR **5**, Rev. 1379].

H. Simpson, USA

3392. **Mercy, G., Eccentrically loaded plane foundations of circular or annular shape** (in French), *Ann. Inst. tech. Bât. Trav. publics* **6**, 62, 145–157, Feb. 1953.

This investigation enables one to determine by means of graphs the normal stresses of annular circular sections in flexure and compression, for which the tensile strength is zero. It is complementary to M. Hahn's results for rectangular sections [idem., Series Z, no. 16]. This case is particularly applicable to foundation soils supporting circular concrete slabs.

Three graphs permit the solution of all cases in terms of ring thickness and eccentricity of the resultant of applied forces. Two further graphs are annexed for plane circular and ring sections.

S. Kirkby, England

3393. **Thomas, F. G., The strength of brickwork,** *Struct. Engr.* **31**, 2, 35–46, Feb. 1953.

Pertinent tests of brick piers and panel walls made at the British Building Research Station are reviewed in connection with a proposed modification of the British Code of Practice. Useful data are presented on the crushing strength of brickwork as a function of brick strength and mortar strength, on the effect of slenderness ratio, and on the effect of eccentricity of loading. Test information is given on cavity or double walls interconnected by metal ties, a type of construction not widely used in the United States. Of particular research interest are load-deflection curves for brick panels subjected to normal or lateral loads and to shearing forces in the plane of the panel. The latter are of special importance in wind-stress and earthquake analyses of multistory buildings.

J. E. Goldberg, USA

3394. **Pappaert, J. M., and Temmerman, M., Note concerning prestressed-concrete girders for roof constructions of industrial buildings** (in French), *Ann. Trav. publics Belg.* **105**, 5, 707–721, Oct. 1952.

Data are given on design and construction of prestressed-precast-concrete roof members for a particular job. Results of vertical displacement measurements during prestressing are presented.

R. B. B. Moorman, USA

3395. **Gabrielli, G., Theoretical weight and actual weight of cantilever wings** (in Italian), *Aerotecnica* **33**, 1, 72–79, Feb. 1953.

3396. **Smith, C. S., and Guttman, L., Measurement of internal boundaries in three-dimensional structures by random sectioning,** *J. Metals* **5**, 1, 81–87, Jan. 1953.

It is shown, from a study of geometric probabilities, that the average number of intercepts per unit length of a random line drawn through a three-dimensional structure is exactly half the true ratio of surface to volume. Since the surfaces can be internal or external, the area of grain boundary or of the interface between any two constituents in a microstructure can be measured. Other metric relations are tabulated that may be of use in studies of the microstructure of polycrystalline, cellular, or particulate matter generally.

From authors' summary

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 3369, 3384)

3397. **Onat, E. T., and Drucker, D. C., Inelastic instability and incremental theories of plasticity,** *J. aero. Sci.* **20**, 3, 181–186, Mar. 1953.

The subject is a paradox of plasticity theory: That plastic buckling tests support the deformation type of theory, though other evidence and arguments support the incremental type. Authors propose to salvage incremental theory by introducing initial imperfections of shape or loading. They consider a hollow thin-walled column, of cruciform cross section, capable of buckling by twist under longitudinal compression. Incremental theory gives the same critical compressive stress as for an elastic column; deformation theory gives a similar formula with the secant shear modulus replacing the elastic. Authors' "imperfection" is a uniform initial twist per unit length. Assuming a simple stress-strain formula to facilitate calculation, they show that a small initial twist changes the critical compressive stress greatly, and that a large initial twist does not change it much more; the results with initial twist present are close to those of the deformation theory. Thus the paradox is resolved in the special case considered.

Reviewer hopes authors will investigate the following question: Formal plasticity theory ignores the microcrystalline structure of metals; it therefore interprets as an imperfection anything dependent on that structure. Will imperfections of this class remove the paradox?

Wm. Fuller Brown, Jr., USA

3398. **Krieger, I. M., and Elrod, H., Direct determination of the flow curves of non-Newtonian fluids. II. Shearing rate in the concentric cylinder viscometer,** *J. appl. Phys.* **24**, 2, 134–136, Feb. 1953.

An alternative method [see AMR **5**, Rev. 1718] was developed for obtaining the rate of shear vs. shearing-stress curves of non-Newtonian fluids from concentric cylinder viscometer data. This method is based on the use of a mathematical expression for the rate of shear which was written in terms of a rapidly converging power series in the logarithm of the ratio between the cup and bob radius. The coefficients of this series are derivatives of the angular velocity with respect to shearing stress. Under favorable conditions only two terms of the series need be used. Apparently, it is seldom necessary to use more than three terms.

B. W. Shaffer, USA

3399. Drucker, D. C., and Stockton, F. D., Instrumentation and fundamental experiments in plasticity, *Proc. Soc. exp. Stress Anal.* **10,** 2, 127–142, 1952.

Paper discusses accuracy, sensitivity, and instrumentation required for investigation of some basic properties of thin-walled metal tubes in the plastic range. Experimental data are presented on the behavior of closed tubes of 24S-T aluminum, 2-in. ID, 0.1-in. wall, under internal pressure and axial pull. Results show that the ratio of diametrical to axial plastic-strain increments is independent of the ratio of the stress increments. This supports the theory that the loading surface is smooth and has no corner or pointed vertex. The maximum shear-stress criterion of yielding and the "slip theory" of Batdorf and Budiansky [AMR 2, Rev. 1264] embody a loading surface with corners.

Considerable space is devoted to: Modifications making an old-style lever-testing machine direct indicating; the use of the SR-4, Type A, resistance-wire strain gage in investigating the plastic range; and the description of a mechanical extensometer which, it is claimed, does not appreciably restrict deformation of metal tube specimen. S. P. Jones, USA

3400. Besseling, J. F., Plastic buckling of columns and plates (in Dutch), *Nat. LuchtLab. Amsterdam Rap.* S.407, 83 pp., 3 tables, 12 figs., Oct. 1952.

Paper is a critical review of the literature. For columns, theories of Engesser, von Kármán, and Shanley are dealt with. For plates, theories based on deformation and incremental as well as Batdorf and Budiansky's slip theory are considered. Author thinks incremental theory should be used and that discrepancies with experiments can be explained by eccentricity, anisotropy, etc.

Reviewer remarks that the idea that incremental theory should be preferred is based mainly on fact that, in tests with compressed and subsequently twisted tubes, initial shear modulus is elastic one. Actually, with buckling, due to unavoidable eccentricities, behavior at superimposed shear strains of order 0.001 is important, for which range the test results are nearer to deformation theory. Recent test with tubes [AMR 6, Rev. 1255 and forthcoming papers] definitely favors deformation theory in this range. P. P. Bijlaard, USA

3401. Orowan, E., Creep in metallic and non-metallic materials, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 453–472, 1952.

A very readable survey of the mechanisms and theories of creep in glass, polymers, and crystals. The main topics are a review of creep phenomena and a discussion of viscous and elastic creep, plastic creep, and the stress and strain fields during creep.

J. C. Fisher, USA

3402. Mellor, G. A., and Ridley, R. W., Creep at 250° and 300° C of some magnesium alloys containing cerium, *J. Inst. Metals* **81,** 245–253, 1952/1953.

Following an investigation [AMR **3,** Rev. 499] of the creep strength of magnesium-cerium alloys at 200 C, tests have now been made at 250, 300, and 316 C, with and without addition of a third element. At 250 C a slight benefit results from additions of silicon and zirconium; silver, lithium, zinc, and cobalt have little influence on creep behavior, and cadmium and aluminum are harmful. The best results at 300 and 316 C were obtained with as-cast alloys containing about 2% cerium or rare earths and 1% manganese. Both rolled and cast alloys of low manganese content can be improved by heat treatment, but cast magnesium-cerium-manganese alloys remain the most creep-resistant.

Examination with optical and electron microscopes showed improvement in creep resistance to be due mainly to the presence of fine precipitates, manganese apparently restraining the coarsening of the Mg_9Ce particles. From authors' summary

3403. Bhattacharya, S., Congreve, W. K. A., and Thompson, F. C., The creep/time relationship under constant tensile stress, *J. Inst. Metals* **81,** 83–92, 1952/1953.

Creep was observed to vary as a power of the time and also as a power of the stress in constant-stress creep tests on copper, zinc, tin, cadmium, lead, aluminum, and lead-tin eutectic.

G. V. Smith, USA

3404. Kuleshov, P. I., On the effect of crystalline structure on the yield stress of a polycrystalline aggregate (in Russian), *Zh. tekh. Fiz.* **22,** 7, 1174–1183, July 1952.

In this paper a maximum shearing stress is used as a criterion for yielding. Author refers slip planes to the directions of principal stresses. He assumes that the yield in the slip plane of an individual grain takes place when shearing stress in this plane obtains the value of maximum shearing stress in tension for the whole material (referred to in paper as crystallographic yield stress). He integrates shearing stresses in the slip planes through the volume containing acting planes. Author accepts this volume to be an elliptical cylinder. He presents the results of his computations for the locus of yield stress in plane stress state, together with Saint Venant and Mises curves.

It appears that he is not familiar with work of Sopwith and Cox [*Proc. phys. Soc. Lond.* **49,** p. 134], in which a very interesting analysis of this problem is given. W. Sylwestrowicz, USA

3405. Ookawa, A., Notes on the crystallite theory of liquid, *J. phys. Soc. Japan* **7,** 6, 543–549, Nov-Dec. 1952.

In specifying the interfaces by the crystallite theory of liquid, author proposes to replace the excess boundary energy by the excess free energy. A correction is also made as to the previous procedure in determining the value of the orientational order parameter. With these modifications the theoretical results can be formulated in considerable agreement with the experimental rules, such as Lindemann's formula as to the melting point, the melting entropy, and Andrade's formula as to the coefficient of viscosity. Just above the melting point, moreover, some abnormalities are expected of the specific heat and of the viscosity coefficient, due to the more or less sharp structural change there.

From author's summary

Failure, Mechanics of Solid State

(See also Revs. 3401, 3423)

3406. de Graaf, J. E., and van der Veen, J. H., The notched slow-bend test as a brittle-fracture test, *J. Iron Steel Inst.* **173,** part 1, 19–30, Jan. 1953.

Notched slow-bend test was described earlier by one of authors [AMR **5,** Rev. 2856]. Present paper includes experimental evidence of earlier statements.

By statistical considerations based on fracture appearance, authors claim that a 3-mm notch is less and the 5-mm notch more severe than the fibrous crack; therefore, a 3-mm notch is used in standard test. Temperature for arrest of crystalline fracture is 10 C higher than fracture appearance transition. Different tests are described to study influence of amount of elastic energy accumulated in construction. Histogram is given of depth of fibrous structure under notch of 379 bend tests, at temperatures not more than 5 C higher or lower than fracture appearance transition. A minimum is obtained at neutral axis of bar.

Desirability of a test, in which work absorbed up to start of fibrous crack and work absorbed during propagation are determined separately, is stressed. Comparison of statistical results show that reliability intervals obtained with impact test for equal number of tests are more than twice as wide as those obtained with notch slow-bend test.

Reviewer considers paper a most valuable contribution to knowledge of testing technique of brittle fracture.

W. Soete, Belgium

3407. Tipper, C. F., Notch bar tests in relation to service performance, Symp., Notch bar testing and its relation to welded constr., Lond., Inst. Weld., 29–33, 1952.

This paper presents a brief examination of the correlation between Izod, Charpy, and notched-bar tension tests and brittle fractures in service. New data are presented for steels from two ship casualties and two special steels. Author concludes that tests which produce fractures similar in appearance to service failures under approximately the same conditions of stress and temperature are better guides to suitability of material than tests which make no attempt to do so.

H. A. Lepper, Jr., USA

3408. Lissner, O., Evaluation of brittle failure tendencies of structural steel by means of notch sensitivity tests (in German), *Arch. Eisenhüttenw.* **24,** 1/2, 27–42, Jan./Feb. 1953.

With method proposed by Kuntze, which uses sharply notched tensile specimens tested with normal and impact velocities (v_0 and v_i, resp.), 130 weldable plain carbon steels of type St 37, 44, and 52 are investigated. From Becker-Crowan's theory of plastic gliding, author concludes that log v vs. the reciprocal of the transition temperature ($1/T_{tr}$) from brittle to ductile fracture should give a straight line. Values of T_{tr} for v_0 and v_i are taken at temperatures where reduction of area ψ is 2%. Security against brittle fracture is higher, the higher the abscissas $1/T_{tr}$ of this line and the greater its slope.

According to experience and special damage cases, this representation gives a proper order of the steels related to their brittle fracture sensitivity. As investigations with small Charpy and sharp Schnadt specimens show, these do not do so in all cases. From his results, author concludes that with the Kuntze method, for sufficient information on brittle fracture tendency, only the two values of ψ for $v = v_0$ and $v = v_i$ at room temperature have to be measured. Minimum values ψ_m for security are found to be 16–22% and 14–20%, respectively. Author states that, by this fact and by simple manufacturing of test pieces, this method has advantages compared with the other methods.

According to reviewer's opinion, this conclusion is not generally valid. Indeed it may be said that a risk for brittle fracture exists for values $\psi \leqq \psi_m$, but no statement on security is possible if $\psi > \psi_m$, because a nearly unique relation between influence of temperature and velocity only exists in the transition region from brittle to ductile fracture, but not above this region, and values of $\psi > \psi_m$ may lie at temperatures near or far from this region. Real measurements of transition temperatures therefore are necessary.

A. Kochendörfer, Germany

3409. Hoyt, S. L., Brittle fracture studies in the United States, Conf. on Brittle Fracture in Steel, West of Scotland Iron and Steel Inst., Glasgow. Paper no. 452, 18 pp., May 1953.

Paper sets out the problem of brittle fracture as seen in the United States and describes some of the investigations in progress in that country and their relationship to similar work that is being done in other parts of the world.

Basic principles are considered briefly, and a substantial part of the paper is devoted to tests of steel. Manufacturing variables are also considered and a bibliography is appended.

From author's summary

3410. Sinclair, G. M., and Dolan, T. J., Use of a recrystallization method to study the nature of damage in fatigue of metals, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 647–651, 1952.

Theory that first stage of fatigue is strain-hardening implies that periodic annealing should increase fatigue life. Tests on 70-30 cartridge brass are described in which specimens were annealed every 20% and 50% of normal life until no significant changes in fatigue life were observed.

R. N. Arnold, Scotland

Material Test Techniques

3411. Förster, F., Theoretical and experimental foundations of nondestructive testing methods using eddy currents. I (in German), *Z. Metallk.* **43,** 5, 163–171, May 1952.

Electric conductivity of materials can be measured with good accuracy by means of an eddy-current detector. The test piece is either placed in the coil of the detector or this coil is placed upon the test piece. The coil is energized with ac, and eddy currents are generated in the material under test. The measurement of the resistance and of the inductance of the coil indicates the conductivity of the material. It has been shown by theory, as well as by experimentation, that the inductance of the coil is an indication of the conductivity of the material, independent of its thickness if the thickness is above approximately 1 mm. The use of a tuned circuit eliminates the effects of oxide films, etc., on the surface.

The reading obtained on such a meter can then be used to identify the material under test. An instrument is being marketed which is using the above principle. It has been used for the following applications: (1) To measure conductivity of wires and rods; (2) to measure the diameter of wires and rods; (3) to measure thickness of foils and sheets; (4) to measure thickness of insulation layers on nonferrous materials; (5) to measure thickness of galvanized layers in nonferrous materials.

The method described can also be used to determine flaws in rods and sheets.

R. O. Fehr, USA

3412. Förster, F., and Breitfeld, H., Nondestructive testing methods using eddy currents. II (in German), *Z. Metallk.* **43,** 5, 172–180, May 1952.

An instrument has been built to measure electric conductivity. It uses the principle of inducing eddy currents in the test piece. The conductivity is read directly on the scale of the instrument. The reading obtained is independent of the shape of the test piece. This instrument has additional applications for determining the conductivity of copper and aluminum and for determining the phosphorous content of copper and its alloys; it has been usefully applied to sort scrap materials. Tests have also been made with this instrument to determine the hardness of aluminum alloys.

The accuracy of the instrument ranges from 0.5 to 1.5% for absolute determination of the conductivity. For comparison measurements, its accuracy is as high as 0.2 to 0.3%. The influence of the size of the area to be measured, of its surface condition as to radius and as to oxide layers is discussed. It should be pointed out that this instrument can be used only for nonferrous metals and their alloys.

R. O. Fehr, USA

3413. Hempel, M., Fatigue tests and behavior of materials under vibration stresses. II. Multistage-repeating tests and change of properties of materials (in German), *ZVDI* **94,** 26, 882–887, Sept. 1952.

This work corresponds to the second part of the lecture given by Dr. Hempel at the Stuttgart Symposium on Strength of Materials, as part of the last meeting of German Engineers Association (VDI).

As is known, fatigue tests are generally systematized, changing the extreme stresses within two limits that remain constant during the test of each specimen. The frequency of these stresses always remains constant. Equally, the limits of these tensions become reduced from specimen to specimen until the amplitude is found which does not cause breaking of the material (with a constant mean stress). In that way the fatigue strength of the material is determined. The object, then, of these systematic tests is to insure that the admissible stresses of the material, in a structure or parts of a machine, do not exceed the fatigue strength.

But the materials of machine parts do not support, during service, that same stress regularity. Dr. Hempel's lecture refers to the state of experiments that try to reproduce these service irregularities. Therefore, he presents with many sketches the different ways in which extreme and medium stresses can vary in each specimen. The change of properties of the said materials during the test can be analyzed.

The author shows the different means by which the change of properties of material can be investigated: mechanical, electric, magnetic, x-ray, metallographic, and theoretical studies on the plasticity and the process of fissure by fatigue. For these he points out the actual absence of knowledge regarding the behavior of the monocrystals in the presence of dynamic changes of stress.

S. A. Delpech, Argentina

3414. Moser, H., On hardness (in German), *Z. Metallk.* **44,** 2, 43–50, Feb. 1953.

Based on Kappler's theory, an expression for the Meyer and Töppl hardness as a function of the load, the elastic constants, (of material and indenter) and two other constants is developed and found valid. For infinite load, the expression gives hardness as a function of one of the latter constants and the elastic constants only, i.e., it enables one to define hardness independent of load.

In reviewer's opinion, hardness at infinite load is physically meaningless. The Meyer hardness at equal diameters of ball and indenter, which is similarly independent of load and still has some physical sense, seems a better quantity. J. H. Palm, Holland

3415. Fry, H. L., An inquiry into the reproducibility of impact test results, *ASTM Bull.* no. 187, 61–66, Jan. 1953.

Charpy and Izod specimens of C1020 normalized and 4340 quenched and tempered steels were tested on five impact machines. Results indicated consistent variation in results between various machines. Author infers that this inherent variation precludes accurate reproducibility of impact test data. Data from other sources are in direct contradiction to author's conclusions. Reviewer feels that several premises in paper are not too well supported and that the broad conclusion is not justifiable on basis of author's data. G. S. Cherniak, USA

3416. Mitchell, N. D., and Ryan, J. V., Fire tests of steel columns encased with gypsum lath and plaster, *Nat. Bur. Stands., Bldg. Materials and Structures Rep.* 135, 14 pp., Apr. 1953.

The results presented are those derived from fire-endurance tests of 16 steel columns encased with gypsum lath and gypsum plasters. The laths were wired into place; those on eight columns were of the $^3/_8$-in. thick perforated type in a single layer, those on seven of the other eight columns were of two layers of the $^1/_2$-in. thick plain type, and on the other a single layer. Six of the latter eight also had a layer of wire fabric to reinforce the plaster. Expanded perlite was used as the plaster aggregate for 13 columns, sand for two, and vermiculite for one. The thickness of the plasters ranged from $^1/_2$ in. to 2 in., and that of the encasements from $^7/_8$ in. to $2^1/_2$ in.

The fire-resistance values indicated by the tests varied with the composition, reinforcement, and thickness of the protective coverings and, to some degree, with the size of the column. The fire-endurance limits, as determined from the tests, ranged from 1 hr 23 min for a 10-in. steel H-section column protected with $^3/_8$-in. perforated lath and $^1/_2$ in. of sanded gypsum plaster, to 4 hr 42 min for one protected with two layers of $^1/_2$-in. lath and a $1^1/_2$-in. thickness of perlite-gypsum plaster reinforced with wire fabric.

From authors' summary by M. J. Manjoine, USA

3417. Farmer, M. H., and Glaysher, G. H., The experimental production of small tensile specimens by electrolytic solution (electro-turning), *J. sci. Instrum.* **30,** 1, 9–10, Jan. 1953.

An apparatus was assembled to turn the gage length of Chevenard tensile specimens, which are only $1^1/_2$ mm in diameter, by electrochemical means instead of by normal lathe turning. The latter causes undesirable surface deformation. Specimens about $^3/_4 \times ^1/_8$-in. (19.0 × 3.18-mm) diameter were rotated at 2000 rpm and moved to and fro along the axis of rotation at constant velocity while a stationary jet of electrolyte impinged radially onto the surface to be removed. Using a hydrochloric acid/copper ammonium chloride solution, the diameter of iron specimens could be reduced by 0.065 in. (1.6 mm) in 15 min and a good polish produced on the surface. The stress-strain curves of normalized pure iron specimens produced by electro-turning and by machining were compared. The yield point, which is easily obliterated by cold work, was shown only on the curves of the electrolytically produced specimens.

From authors' summary

Mechanical Properties of Specific Materials

(See also Revs. 3402, 3558)

3418. Sykes, C., Developments in alloy steels: A review of recent progress, *Metallurgia, Manchr.* **47,** 279, 3–8, Jan. 1953.

The relative scarcity of certain alloying elements has influenced considerably the developments in alloy steels during the last year or two. Not all the work has been directed toward substitute finding, however, and some of the principal items investigated are reviewed here. Although the main emphasis is on the field of corrosion and heat-resisting steels where the effort has been greatest, reference is also made to high-speed steels, boron steels, and the use of the rare earths as alloying elements.

From author's summary

3419. Polakowski, N. H., The Bauschinger effect in iron single crystals, *Research, Lond.* **5,** 3, 143–144, Mar. 1952.

Bars of several large crystals were pulled in tension to 9% strain. Single crystal specimens $0.45D$ by 2 in. long cut from these bars indicated an apparent Bauschinger effect. Orientations were not determined. Reviewer points out that for certain orientations, elastic anisotropy will produce a shear deformation and nonaxial loading. It is possible that the resulting moments were the cause of the Bauschinger effect observed in these experiments. F. A. McClintock, USA

3420. **Gilman, J. J., and Read, T. A., Bend plane phenomena in the deformation of zinc monocrystals,** *J. Metals* **5,** 1, 49–55, Jan. 1953.

Inhomogeneities of deformation which occur at the restrained ends of zinc crystals, at tensile kink bands, and at compressive kink bands are described in terms of bend planes which are believed to consist of walls of edge dislocations.

From authors' summary

3421. **Sweetland, E. D., and Parker, E. R., Effect of surface condition on creep of some commercial metals,** *J. appl. Mech.* **20,** 1, 30–32, Mar. 1953.

The secondary, or quasi-viscous, creep rate of commercially pure aluminum and drawn copper wire was measured, in an inert atmosphere furnace, after stripping of oxide film from specimen. Admission of air into furnace perceptibly diminished creep rate. Presence of surface oxide thus increased creep strength of parent metal. Authors conclude that oxide films inhibit formation and/or migration of growth dislocations at metal surface, consistent with theory of dislocations as presented by G. I. Taylor. Hence, metals for high-temperature use should be tested under conditions leading to surface oxidation encountered in service. (Reviewer's note: Surface condition influences tensile strength, and presumably creep, of polymethyl methacrylate also. See AMR **5,** Rev. 136.) J. T. Bergen, USA

3422. **Schwartz, B., Thermal stress failure of pure refractory oxides,** *J. Amer. ceram. Soc.* **35,** 12, 325–333, Dec. 1952.

An investigation was carried out to study the thermal stress failure of three pure, dense refractory oxides, namely alumina, stabilized zirconia, and magnesia. Thermal stress resistances were determined by means of a direct test and by calculation from the physical properties of the material. The properties measured included strength, elasticity, and thermal expansion. All the tests were conducted within the temperature range 25 to 1500 C. For hollow cylindrical specimens, heated uniformly from the inner surface, resistance to fracture was expressed quantitatively by the heat flow at steady state required to cause fracture. This resistance was found to be a function of (1) the physical properties of the material, (2) the temperature range of testing, and (3) the temperature distribution within the specimen.

From author's summary

3423. **Freudenthal, A. M., The inelastic behavior and failure of concrete,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 641–646, 1952.

Author criticizes recently developed "plastic" design procedure for concrete similar to that of structural metals. As concrete is a viscoelastic material made up of elastic stone aggregate suspended in a (very) viscous cement paste, the deformational response of the material significantly depending on the volume concentration of the "solid phase," there is no "yield point" as in metals. The so-called plastic redistribution of stresses is, in fact, the result of a localized fracture process, the spreading of which along a shear plane is temporarily blocked by the lower stresses in the surrounding material. While in metals the truly plastic redistribution of nonuniform stresses is gradual and continuous, in concrete there is a sharp discontinuity of behavior with suddenly spreading fracture by shear. This sets in when a fracture surface can propagate between two points at which local destruction has taken place. This would explain the higher compressive strength of beams in comparison with cylindrical specimens.

In support of this theory, compression tests on $r = 2$ in. cylinders of various mixes with circumferential notches 0.1 in., 0.2 in., 0.5 in. deep were performed. From elastic theory, stress concentration factors of 3.73, 2.73, 1.93 were calculated. Assuming failure to be governed by critical stress $\sigma_e^2 = (\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2$, depending upon the isotropic stress component p through $\sigma_e = c_1 p + c_2 \sigma_0$ where $\sigma_0 = P/\pi r^2$, it was found that, for the same mix, c_1 decreased and c_2 increased with increasing depth of notch. Author maintains that this proves fictitiousness of computed elastic stress values. Results were compared with recently reported triaxial tests by Bureau of Reclamation, in which both axial compression and hydrostatic pressure are known.

M. Reiner, Israel

3424. **Biadene and Pancini, Efficiency of the addition of pozzolan to the cements for mass concrete and their recent applications in Italy** (in French), *Trans. Fourth Congr. Inter. Comm. Large Dams,* New Delhi, Jan. 1951 (in 4 vols.), vol. III, pp. 445–476. $48 per set.

3425. **Higgins, H. G., Factors influencing the plastic deformation of timber and plywood in compression,** *Austral. J. appl. Sci.* **4,** 1, 84–97, Mar. 1953.

Oven-dry, matched, Australian hoop pine was tested between steel platens at constant compressive load of 1000 psi applied perpendicular to the grain of the wood at constant temperature of 140 C, in order to determine plastic deformation during 30-min load application. Angle of growth rings and shape of specimens influenced the relatively variable test data.

Phenol-formaldehyde resin-film bonded, rotary-cut, $^1/_{16}$-in. plywood of same material, having a moisture content of 10%, provided more consistent test data. It was pressed under constant loads of 600 to 1400 psi at 20 C temperature and 60% relative humidity, for 1-, 5-, and 30-min periods, during which residual deformations were noted. At large pressures, duration of loading appeared to be of considerable influence on residual deformation.

The effect of time upon total deformation of above material under similar loading within 1 to 8 sec was determined after 30-min load application. Incipient fracture of the cell walls of the specimens was found at 1250 psi, and crushing at 1500 psi.

Glue penetration into the wood was not observed when hot-setting phenolic glue film was used. When cold-setting urea-formaldehyde resin bonded the veneer layers, some penetration occurred which influenced the test data on oven-dried plywood panels under pressure for 5 min at 140 C; that is, reduced residual deformation.

Residual deformation of plywood panels, having various moisture contents below the fiber-saturation point and under constant pressure for 5 min, increased with increase in moisture content, while yield values decreased.

Additional plywood panels of radiata pine, oak, ash, walnut, yellow-wood, and karri, thus representing a wide range of density, were conditioned at 20 C and 60% relative humidity and subjected to 1000 psi pressure for 5 min. The effect of wood species appeared to lie mainly in difference in density rather than wood structure. E. G. Stern, USA

3426. **Zwietering, P., Pore structure of porous materials** (in Dutch), *Ingenieur* **65,** 8, 0.1–0.8, Feb. 1953.

Author gives a survey of experimental methods for the determination of pore structure of porous materials. The merits of the various methods are illustrated by the results of his own experiments. Total volume of pores (radius $< 75{,}000$ Å) is determined from the difference in density of the evacuated sample in mercury

and helium at atmospheric pressure. Total pore surface is determined according to the BET technique (Brunauer, Emmett, and Teller), from the adsorption of an indifferent gas (e.g., N_2) at subcritical temperatures and at rather low relative pressures (p/p_0 = 0.05–0.3). The total surface of both-sides-open macropores is determined from the resistance to gas flow as a function of pressure difference. The distribution of pore radii is determined from the desorption-isotherm at high relative pressures (p/p_0 = 0.4–1.0), a method based on the theory of capillary condensation, or by measuring the density of the sample in mercury as a function of the pressure (Ritter and Drake).

The methods of Shull and Barrett, for correcting the results with regard to the adsorption of multi-molecular layers, are discussed. The radius of submicroscopic pores ($r < 10$ Å) can also be determined by desorption measurements, but then a revised formula for multi-molecular adsorption must be used, derived by Brunauer, Emmett, and Teller, in which the maximum number of layers is assumed to be limited by the size of the pores. Another method is to do adsorption measurements with molecules of increasing size.

Author describes his experiments on samples of Al_2O_3, active carbon, and silica-gel, using the afore-mentioned methods. For the macropores of his Al_2O_3 sample, he finds a mean radius of 6600 Å, a surface of 1.7 m^2/g, and a volume of 0.56 cm^3/g; for the micropores, a surface of 180 m^2/g and a volume of 0.43 cm^3/g are found, whereas the distribution curve of pore radius shows two maxima (20 Å and 40 Å, respectively). The silica-gel sample contained almost only micropores (volume 0.431 cm^3/g, surface 572 m^2/g, radius approx. 10 Å). The sample of active carbon was found to contain submicroscopic lamellae (d = 13.8 Å, total surface 1403 m^2/g, total volume 1.108 cm^3/g).

J. H. van der Veen, Holland

3427. Frenzel, W., and Liebscher, U., The manufacture of flax fabrics by means of spinning pot drives (in German), *Faserforsch. Textiltech.* **3**, 9, 10; 356–373, 390–400, Sept., Oct. 1952.

The aim of the authors is to examine if top spinning, which has been in use for rayon for some years, is adaptable to flax spinning. A ring-spinning machine was therefore transformed; it was fitted with a top spindle driven by a special electric motor, the speed of which could be varied by a frequency converter.

Several problems in connection with the disposition and the strength of the pot, the movement of the thread guide, the measure of the thread tension are treated. A new thread guide was deduced from experiments on different types.

From measures made on the spinning tension of the thread, and from a comparison of the experimental values with the calculated ones, a "reception coefficient" was derived, with the aid of which a monogram could be traced, giving the thread tension as a function of the pot diameter and the spindle speed.

Numerous experiments were made to find the influence of different factors—speed of the spindles and of the roving, draft, water temperature, setting—on the properties of linen and tow yarn. The optimum conditions for pot-spinning flax yarn were deduced from those experiments and compared with the results obtained in flyer and ring spinning. It was found that in respect of strength and uniformity, top yarn is superior to the yarn obtained by the two other methods. This result must, according to the authors, be attributed in first order to the small drawing of the yarn during spinning.

The possibilities in handling the cakes after spinning are considered.

Taking into account the low manufacturing costs and the high quality of pot-spun flax yarn, authors conclude from their results that, notwithstanding the great expense of the pot-spinning machine (35,000 DM against 24,000 DM for a flyer- or ring-spinning machine), the introduction of this process in the flax-spinning mills would afford great advantages in regard to manufacturing costs, production, and quality of flax yarn.

D. De Meulemeester, Belgium

3428. Hannah, M., Applications of a theory of the spinning balloon, *J. Text. Inst., Trans.* **43**, 10, T519–T535, Oct. 1952.

The mathematical theory of the motion of a rotating thread has been worked out, taking into account air resistance assumed to vary as the velocity squared. The results are applied to show how the shape and tension of the balloon in normal cap spinning depend on air drag, cap size, bobbin size, and balloon length. Licking round the cap is discussed, and it is shown how the behavior of the balloon depends on the friction between the yarn and the cap surface, and on the shape of the cap. The results are found to check satisfactorily with experiments by other workers (Wool Research, 1918–1948, **6**, chap. 8 and 9, Wool Industries Research Association, Leeds, 1949). D. J. Montgomery, USA

3429. Frenzel, W., and Perner, H., Investigations on torsional resistance. Determination of torsional resistance and breaking twist of fibers and yarns by means of a new testing apparatus and their significance for spinning and twisting (in German), *Faserforsch. Textiltech.* **4**, 1, 2; 1–14, 63–74; Jan., Feb. 1953.

An apparatus is described recording the stress produced in a yarn twisted under constant length. This instrument records, among others, the "breaking twist" and the "torsional resistance" which, respectively, mean the number of revolutions necessary to break the yarn held under constant length, and the stress supported by the yarn at that breaking twist.

After a short review of the notions on tolerance, authors devote the greater part of the paper to the study of the influence, on the two above-defined properties, of several factors.

The twisting velocity, the length of the specimen, the initial stress, the direction of twist, the count of the yarn, the nature of the material (cotton, flax, wool, etc.), the number of specimens twisted, the initial twist are the objects of this study.

From indications so gathered, normal conditions are deduced for examining other questions, such as the effect of twisting and untwisting yarns with the incidence of those operations on elasticity, and the effect of wetting the yarn. The length variation caused by yarn twisting and the behavior of single fibers and filaments when twisted are also studied.

The results show some analogy with the stress-strain diagrams. They can be useful for avoiding end-downs in spinning and twisting.

D. De Meulemeester, Belgium

3430. Marx, J. W., and Sivertsen, J. M., Temperature dependence of the elastic moduli and internal friction of silica and glass, *J. appl. Phys.* **24**, 1, 81–87, Jan. 1953.

Paper describes measurements at 37 kcps over temperature range of −170 C to 1000 C. Results show maxima in internal friction at high temperatures, minima at low temperatures. Probable causes are given as viscous damping at higher temperatures, combined with stress-induced diffusion of sodium atoms. Low-temperature minima are taken as indication of peak at still lower temperatures due to possible changes in silica structure. Variation of dynamic Young's moduli with temperature is shown.

Composite piezoelectric oscillator is used, with interesting arrangement to achieve uniform temperature over specimen length and maintaining interface between driver and specimen at room

temperature. This is a variation of earlier method reported in *Rev. sci. Instrum.* **22**, p. 503, July 1951.

H. I. Fusfeld, USA

Mechanics of Forming and Cutting

3431. Metal cutting tool handbook, 2nd ed., New York, Metal Cutting Tool Inst., 1950, 647 pp.

The Metal Cutting Tool Institute has performed valuable service to the metal-working industry by compiling in one book tabulations of standard dimensions of various sizes and types of the seven most important cutting tools, with instructions on use, application, maintenance, tool angles, cutting speeds and feeds, use of cutting fluids, holding means and tapers, resharpening; suggestions for cure when encountering difficulties in operation; information on special types and dimensioning when requesting new tools. Material is divided into seven sections, beginning with drill section, followed sequentially by sections on reamers, counterbores, taps and dies, milling cutters, hobs and gear shaper cutters, and broaches. An engineering data section concludes the book, which is valuable to shop men, production engineers, tool engineers, and to anyone connected with cutting-tool application, use, and maintenance. Value of the book is reduced by absence of section on single-point tools for turning and boring operations. Editing leaves much to be desired in quality of writing, in too condensed index, no cross indexing, and accuracy and consistency of definitions. M. Martelotti, USA

3432. Van Horn, K. R., Residual stresses introduced during metal fabrication, *J. Metals* **5**, 3, 405–422, Mar. 1953.

Author investigates the origin and control of residual stresses introduced during metal fabrication. He indicates how stresses originate by plastic deformation under forming operations, nonuniform thermal contraction, or a volume change during a phase transformation within the temperature range of cold work. He considers examples of beneficial and detrimental residual stresses.

Author also discusses mechanical and x-ray methods of measurement, and investigates the effect of fabricating practices on the residual stresses in aluminum alloys. He shows the influence of quenching temperature, quenching rate, section size, surface condition, and the composition, thermal, and mechanical properties of the material. Also discussed is relief by mechanical and thermal treatments.

Paper serves as an excellent background for quantitative investigations on residual stresses. H. H. Dixon, USA

3433. Hucks, H., Plasticity-mechanical theory of chip formation (in German), *Werkstatt u. Betrieb.* **85**, 1, 1–6, Jan. 1952.

A formula is derived for orthogonal cutting relating the shear angle Φ, the angle of inclination φ between the slip plane and the plane of maximum principal stress, the rake angle γ, and the coefficient of friction μ between chip and tool

$$\Phi = \varphi + \gamma - 0.5 \arctan 2\mu$$

Angle φ would be 45° if there were no influences of normal stress on shear strength and, in general, is less if the hypothesis of Mohr is followed.

The major assumption leading to the formula is that there is no normal stress in the chip on planes perpendicular to the tool-chip interface. This seems unreasonable to this reviewer. Discussion of effect of varying speed of cutting, depth of cut, chip formation, and properties is given in some detail. All work in the United States after 1945 is ignored, much of which is most pertinent to the paper. D. C. Drucker, USA

3434. Witthoff, J., Determination of the most favorable working conditions in cutting processes (in German), *Werkstatt u. Betrieb.* **85**, 10, 521–526, Oct. 1952.

High cutting speeds reduce cutting time and labor cost. On the other hand, increasing speed shortens tool life and raises grinding time and cost per production unit; therefore, total time and cost at certain cutting speeds have a minimum. Minimum of total costs corresponds to medium speeds, minimum of production time corresponds to high, but not to the highest attainable speeds. From these considerations, with the assumption that the cutting speed is a power function of tool life, author deduces the tool endurance for lowest total cost and minimum production time. Formulas easy to use in the case of rotating and oscillating motion are given; some examples are worked out.

H. Krüger, Germany

3435. Siebel, E., The straightening of rolling mill products, *Stahl u. Eisen* **72**, 21, 1298–1301, Oct. 1952.

Methods of straightening rolled sections are discussed, such as those employing presses, rolls, stretching machines, and localized heating. The mechanics of straightening with the resulting residual stresses is treated in the case of press and roll straightening. Approximate formulas for the required deflections as a function of the bending span are presented, with a rough approximation for residual stress in the case of round and square sections. The straightening properties of other sections are discussed qualitatively. W. Schroeder, USA

3436. Stone, M. D., Rolling of thin strip, *Iron Steel Engr.* **30**, 2, 61–73, Feb. 1953.

The author's simplified theory of rolling thin strip, and particularly of cold-rolling it, is based on the assumption that the material between the rolls is essentially a flat strip, because of the flattening of the rolls under the action of the total pressure or separating force (for which the author introduces the term "rolling force"). This assumption is used solely for the determination of the rolling force, as it fails to explain other features of the rolling process, such as pressure distribution and forward slip ("extrusion effect"). The problem then becomes simply that of compressing a flat narrow strip in the presence of friction at the interface. According to the elementary theory of plasticity, this leads to the following equation for the mean roll pressure $\bar{p}$

$$\bar{p} = (S_0 - S)\left[(e^{\mu L/t} - 1) \Big/ \frac{\mu L}{t}\right] = (S_0 - S)[P.M.F.]$$

where S_0 is the "constrained" mean yield strength of the strip material, S is the external tension applied laterally to the strip, μ is the friction coefficient, L is the contact length between strip and flattened rolls, and t is the strip thickness.

The complex factor at the right side of the formula is called "pressure-multiplication factor"—*P.M.F.* It is a function of the quantity $\mu L/t$. This simple factor takes account of the fact that the roll pressure may be many times larger than the yield strength of the rolled metal, while more advanced theories of rolling require tedious calculations to arrive at substantially the same values.

The author then proceeds to discuss the values of other quantities in the above equation. Regarding the contact length L for flattened rolls, it is now generally agreed that the Hitchock equation offers a good approximation, for which the author gives a simplified expression to be used in his analysis. For the thickness, its average value, $t = \frac{1}{2}(t_1 + t_2)$, is taken, where t_1 is the entry thickness and t_2 is the exit thickness of the strip. The value S_0 is called by the author "constrained yield stress." It is 1.15 times

the average yield strength of the metal in the range of reductions performed. For the "external tension" s, the average value of front tension and back tension (stresses) is taken and it is shown that this adequately takes care of the tension effects.

Regarding the friction coefficient μ, recent investigations showed that, for common lubricants, this value depends considerably upon the speed. The development of the author's formula permits determining the friction coefficient from the rolling force, the strip tensions, and the yield strength of the metal. Evaluation of earlier such data leads to the conclusion that in rolling steel strip the friction coefficient first decreased from 0.10 to 0.03 as the speed increased to about 1500 rpm, and then remained essentially constant at higher speeds. This explains the thickness variations encountered in commercial rolling of steel strip.

The author proceeds to demonstrate the procedure of calculation for the rolling force. He then determines the limits of rolling imposed by the fact that a combination of high values of yield strength and high values of $P.M.F.$ yields such high pressures that it causes the rolls to deform instead of the strip to be reduced. This means that in order to continue rolling of a strip with a mill having a given work-roll diameter the strip must be annealed, and thus further reduction will become possible by reducing the yield strength of the metal. These limiting conditions have been analyzed by the author and a general solution is presented. The following formula yields the (average) minimum thickness $t_{\min}$ to which a metal can be rolled with working rolls of a given diameter D: $t_{\min} = 3.58\, D\mu(S_0 - S)/E$. Using probable values of friction coefficient, the following roll diameter-to-thickness ratios, $D/t_{\min}$, were determined by this equation, in agreement with practical experience

Aluminum (foil) — 9000:1
Tin plate (low-carbon steel)—highspeed—4000:1
Stainless steel—low speed—500:1
—high speed—1000:1

In these calculations, the tensions applied were taken to be 45% of the yield strength of the hard material for aluminum, 40% for tin plate, and 20% for stainless steel.

In practice, the most economical solution of rolling-mill practice requires that the tensions be kept as high as possible and the work-roll diameter be made as small as possible. It appears that mills with driven backup rolls offer particular advantages in this respect. G. Sachs, USA

3437. Datsko, J., and Boston, O. W., Relative abrasiveness of the cast surfaces of various gray-iron castings on single-point tools of high-speed steel, *Trans. ASME* **75,** 1, 103–108, Jan. 1953.

This study reveals that plain gray-iron castings made in sand molds have a very abrasive surface that results in a low tool life when machining the surface. This condition can be eliminated almost completely by pickling the castings prior to machining. Annealing improves the machinability of the casting, but it also results in a more pronounced "skin effect." By means of an annealing and pickling treatment, the cutting speed for removing the surface was increased by 230%.

From authors' summary

3438. Klein, A. M., and Crockett, J. H. A., Forging-hammer foundation built to control destructive vibrations, *Civ. Engng., N.Y.* **23,** 1, 30–36, Jan. 1953.

The new-type foundation, built for International Nickel Co., here described employs heavy springs to cushion the steel anvil in every direction, as well as cushioned blocks of very high-strength concrete to carry the 8-ton steam-actuated hammer and the steel anvil. This installation bids fair to improve production from nickel and nickel-alloy ingots by eliminating many costly maintenance delays due to fatigue failures in hammer and foundation.

From authors' summary

3439. Hunter, R. S., Gloss evaluation of materials, *ASTM Bull.* no. 186, 48–55, Dec. 1952.

To materials engineers and technologists, gloss is a property of surfaces which causes them to have a shiny or mirrorlike appearance. This appearance cannot be measured; only specific reflectance capacities of surfaces can be measured. Although gloss may be associated with the capacity of a surface to reflect like a mirror, there is no single reflectance scale yielding values that correlate with the glossy appearance of all surfaces. This is because the capacities of surfaces to reflect light in and adjacent to the directions of mirror reflection are too complex and varied to be compared on any single scale. As a consequence, different gloss scales involving different geometric aspects of light reflectance have been developed. From author's summary

Hydraulics; Cavitation; Transport

3440. Mostkov, M. A., Modification of the method of integration of the equation for nonuniform liquid flow (in Russian), *Gidrotekh. Stroit.* no. 10, 32–35, Oct. 1951.

Author considers steady nonuniform flow in open channels under the assumption that only gradual change in motion occurs. The local change in energy content $[h + (\alpha v^2/2g)]$ in cross section concerned is determined by the local slope of the bed i and resistance head i_f. The equation so obtained is integrated under the assumption that the friction head i_f can be represented by a function of the average energy content in the section of stream considered. The calculation for wide channel with rectangular cross section is carried out. M. Strscheletzky, Germany

3441. Guman, E., Computing natural gas pipe lines, *Acta Techn. Hung. Budapest* **5,** 4, 397–434, 1952.

3442. Rahm, L., Flow problems with respect to intakes and tunnels of Swedish hydro-electric power plants, Dissertation for doctor's degree, Bull. Instn. Hydraulics, Roy. Inst. Technol., Stockholm, 219 pp., 1953.

The first seventy pages contain a description of the flow patterns in front of the intakes to six Swedish hydroelectric power plants.

Pages 71–117 are devoted to model tests. Water flows through a vertical tube, which traverses the bottom of a test tank. For Binnie's four different types of flow, the discharge formulas are found.

"Friction losses in unlined Swedish rock tunnels" are dealt with in pages 118–213. When blasting a tunnel, it is practically impossible not to exceed the desired minimum cross section. The cross-sectional area, therefore, varies a good deal. This variation has a greater influence on the loss of head than the roughness of the surface. Author finds the following formula for the loss of head (page 199): $h_f = flq^2/8gR_eA_e^2$ where, for the Swedish plants investigated, $f = 0.00273\ \delta$, l is the length of tunnel, q the discharge, R_e is Reynolds number vd/ν, A_e is the effective cross-sectional area of the tunnel, g is the gravitational acceleration. Approximately, the loss of head is $h_f = 73\, lq^2\delta/A^{2.5}\,(200 + \delta)^{2.5}$.

To find δ, author draws frequency diagrams for the cross-sectional areas at equal distances in the tunnel. On a standard distribution paper, a plot is made of the per cent number of sections which have an area less than the ordinate indicates; thus a rising curve is obtained. Author approximates the curve by a straight

line so that the weighted areas to the left of the 50% line are equal beneath and above the straight line. The areas are limited by the curve. The same shall also hold good to the right of the 50% line. This straight line intersects the 1% ordinate at y_1 and the 99% ordinate at y_{99}. Then $\delta = (y_{99} - y_1)/y_1$.

As the above resistance formula holds good for all Swedish plants investigated up to the present, it is a very important result. It can very likely be applied to all tunnels, blasted in the same way as is usual in Sweden. O. H. Faxén, Sweden

3443. Lee, M., Babbitt, H. E., and Baumann, E. R., Gradually varied flow in uniform channels on mild slopes, *Univ. Ill. Engng. Exp. Sta. Bull. Ser.* no. 404, 90 pp., Nov. 1952. $1.

The basic assumptions leading to the equation of gradually varied flow in canals and the graphical integration, the step method, and the methods of Bakhmeteff and Mononobe are discussed at some length. The first two methods suppose that computations are made in small steps; the method of Bakhmeteff assumes the velocity head changes to be negligible. The proposed method of integration differs from Bakhmeteff's method so much as velocity head variations are now being considered. The new formula adds a further term to Bakhmeteff's formula. Bakhmeteff's well-known tables are extended to suit the new method, which is also claimed to be more simple in use than the graphical charts prepared by Mononobe.

Results obtained with the different methods are compared with actual flow measurements and show the new method to be reliable. C. Jaeger, England

3444. Spronck, R., Similitude of flows over thin-walled weirs at small water heights (in French), *Rev. Univ. Min.* (9) **9**, 3, 119–127, Mar. 1953.

The author, who has already issued several important works on hydrodynamic similitude and, on the other hand, on the discharge of variously viscous liquids, now studies the conditions to be met by thin-walled weirs working with small water heights, so as to make possible hydrodynamic similitude.

This study is based on the experimental works of the author and of Hanocq, Baar, Jorissen, Schoder, and Turner, and on the theoretical works of Staus and Von Sandem. It is given over to the case of rectangular, triangular, and circular weirs, and investigates the influence of inertia, gravity, capillarity, and viscosity. The author concludes by pointing out how complicated the phenomenon is, and practically how difficult it is to obtain similitude of flows with small water heights. L. Escande, France

3445. Bleines, W., Calculation of the flow over sharp-edged weirs by means of the extremum principle (in German), *Wasserwirtschaft* **43**, 4, 97–102, Jan. 1953.

The extremum principle is stated as maximum discharge at given specific energy level, or minimum energy level at given discharge where transition occurs from tranquil to rapid stage of flow. For a theoretical discussion of the principle see Jaeger, C. [*Bull. tech. Suisse Rom.* **69**, 16, 17; 185–192, 200–203, Aug. 1943].

Author attempts to derive a theoretically sound formula for the case without tail-water influence and without side contraction. For the derivation, it is assumed that the vertical section through the crest of the lower free surface is the critical section for which the extremum principle applies. Of the assumed parabolic velocity distribution, the coefficients are computed with this principle from empirically known shape of boundaries and energy loss. Resulting expression for discharge is compared with known empirical formulas. Differences are between $+ 3\frac{1}{2}$ and -2%.

The application of experimentally determined numerical values and simplifications detract from the theoretical interest of the work. H. J. Shoemaker, Holland

THE FOLLOWING PAPERS (REVS. 3446–3457) WERE PUBLISHED IN *Trans. Fourth Congr. Inter. Comm. Large Dams*, New Delhi, Jan. 1951, 4 vols. $48 per set.

3446. Coutagne, A., Methods for determining the maximum flood discharge that may be expected at a dam, and for which the dam should be designed (in French), vol. II, 687–712.

General methods of maximum flood estimate are examined from a critical point of view. Concerning the probability method (1), comparison is made between various suitable formulas. Those of Galton and Gumbel, which author applies on eleven basins in Europe and USA, are most interesting, leading to nearly identical results. In fact, both formulas correspond nearly to the linear expression $Q = Q_0[1 + K \log T]$, as proposed in 1914 by Fuller, where Q is the maximum, Q_0 the dominant discharge, K a coefficient, and T the return period. In a diagram (Q, log T), this straight line is the tangent, starting from a certain value of T, approximately = 100, to the curve of Gauss, which cannot be extrapolated beyond a certain limit. The topographical method (2) leads to empirical expressions involving the main characteristics of the basin, especially its area S. To the correlation curve between areas and maximum corresponding floods can be given an expression as $Q = AS^n$, where A and n are coefficients. Author examines, from this point of view, some French regions and basins; the most suitable value for n is about 0.5. Method (3), resulting from some rainfall/river flow correlations ("Units Hydrographs Method"), is, in practice, rather difficult to use. Author remarks that each of the above methods is only a side of the same complex problem, which consists of expressing the annual flood discharge as a function of geographical and climatical factors, and of the duration factor; so a flood formula is necessarily a probability formula, more or less applicable to specific cases and particular regions. A. Ghetti, Italy

3447. Drouhin, Mallet, and Pacquant, Contribution to the study of rate of flow and determination of flood discharge (in French), vol. II, 461–521.

First part of paper deals with main aspects of headwater control, with special regard to Algerian rivers. Well-known methods for flood flow estimation, both statistical and empirical, are summarized briefly and applied to same Algerian rivers. Second part is devoted to description and critical review of spillways and sluice gates for dams, again with particular regard to Algerian rivers.

In third and last part, basic problems of flood routing are treated. Equation of continuity for a reservoir-spillway system with given inflow is considered in simplified form, neglecting wave propagation effects. Step-by-step methods of integrating such equation, both numerical and statistical, are recalled and applied to actual cases. G. Evangelisti, Italy

3448. Blizniak, E. V., Methods applied in the USSR for computing maximum flood flows of rivers, vol. IV, 557–577.

A survey is made of methods for predicting maximum flood flows currently being used in the USSR. Probability methods, indirect methods, and the so-called "genetic method," which appears to be a title describing run-off studies which take cognizance of geological and meteorological factors, are discussed. Numerous empirical formulas are cited, usually without giving restrictions as to applicability and sources where the many empirical coefficients involved in these formulas may be obtained.

L. Talbot, USA

3449. Grzywienski, A., Anti-vacuum profiles for spillways of large dams, vol. II, 105–124.

Three crest types were investigated theoretically and with models in an endeavor to fulfill the conditions (a) of an economic profile that would harmonize with the required dam base, (b) of avoidance of partial vacuum on the surface, and (c) of a profile having a large discharge capacity.

Type I profile corresponded to the shape of the nappe from a sharp-crested weir, the so-called Bazin profile. Type II profile had a uniform transition instead of a sharp-crested one. Type III had an approach nose extending upstream from the face of the dam and the crest was directly over the face of the dam, thus producing an economical profile.

The discharge capacity of the three types was comparable with μ values of 0.733, 0.737, and 0.740, respectively. The author concluded that the Type III profile should be used wherever possible, otherwise Type II should be used. G. N. Cox, USA

3450. Williamson, J., Round-crest, syphon and trumpet shaft spillways, vol. II, 267–299.

Author discusses design and associated problems of these types of spillways, principal attention being paid the latter two. Several examples are worked out illustrating the head losses and control of pressure throughout the systems. The limitations and inadequacies of model-testing are pointed out.

H. G. Farmer, Jr., USA

3451. Marcello, C., The dam of Villa di Chiavenna (Lombard Alps, Italy) (in French), vol. IV, 381–398.

3452. Ehrmann, P., Problems pertaining to earth and sand removal from the auxiliary water intake of the Courbaisse waterfalls (in French), vol. IV, 237–256.

3453. Rao, K. L., and Raghavachari, S., Sedimentation of reservoirs in the state of Madras, vol. IV, 257–270.

3454. Hoon, R. C., Silting of reservoirs: with special reference to the proposed reservoirs of the Mahanadi and the Kosi, vol. IV, 271–295.

3455. Joshi, N. S., Silt deposition in tank-basins in trap-rock zones with 20 to 30 inches annual rainfall, vol. IV, 321–353.

3456. Suleiman, H. B., Silt deposition in the Aswan Reservoir, vol. IV, 356–369.

3457. Holecek, Vl., Establishment of reservoirs on the middle Vah, in Czechoslovakia, with intense sediment carriage (in French), vol. IV, 371–380.

3458. Smirnov, D. N., Factual data on water hammer in a conduit of considerable length (in Russian), *Gidrotekh. Stroit.* no. 9, 29–33, Sept. 1952.

Incompressible Flow: Laminar; Viscous

(See also Revs. 3293, 3503, 3603)

3459. Prandtl, L., Essentials of fluid dynamics with applications to hydraulics, aeronautics, meteorology and other subjects, New York, Hafner Publ. Co., 1952, x + 452 pp. $6.

This English translation of the third (1949) edition of Professor Prandtl's "Fuhrer durch die Stromungslehre" makes available to a wider group of readers a work which has already become a classic. It is a masterful descripto-analytical tour through an immensely broad domain in fundamental and applied fluid mechanics, done from the point of view of engineering and macroscopic mechanics (as contrasted with mathematics and/or more general physics). The breadth is suggested by a tabulation of some of the general topics treated: Fluid statics; kinematics; dynamics of inviscid liquid; free surface flows and waves; gas dynamics; dynamics of viscous liquid, including both laminar and turbulent flows; multiphase flow; flow of stratified fluids; rotating bodies and systems of reference; heat and mass transfer in laminar and turbulent flows with free and/or forced convection. Applications are made to the following: Airfoil and wing theory; propellers, windmills, turbines, etc.; resistance of a solid body; planing surfaces; bearing lubrication; assorted meteorological phenomena; etc.

The emphasis is on physical description and explanation of phenomena, but mathematical formulations are freely included wherever they aid in explanation and exist. The forms are chiefly initial equations or final solutions; intermediate analytical details are deliberately omitted.

The book seems virtually ideal for the reader who is already expert in a narrow phase of fluid mechanics or another branch of applied mechanics or physics. For beginning student use, the space-dictated omission of details must be compensated either by a first-rate instructor or by direct contact with the original literature accompanied by suitable lectures; the book might well be used for a first course in fluid mechanics at the senior or graduate level.

References to the German literature are exhaustive, and the British have appended an auxiliary bibliography of recent pertinent work in Britain and the United States. The book is well made up, relatively free of misprints, and the English is good (translated by Miss W. M. Deans).

It is, of course, inevitable that differences of opinion exist on didactic matters, and the reviewer finds a number of specific places where the exposition could be clearer. For example, on p. 37 it seems to be implied that the continuity equation is not applicable to flows with mixing of two or more components; there is no mention of surface tension as surface energy; transition Reynolds numbers are tabulated in too positive a fashion, as though the problem were all simple and settled; no explicit mention is made of the similarity assumption used in the jet analyses on pp. 122–123; he identifies Eulerian turbulence scale with mixing length—in fact, Lagrangian scale (not mentioned) is a closer cousin; on p. 256 it is implied that the wake survey method of measuring drag through momentum defect detects only profile drag and not induced drag of wings—this is true for a vertical line survey, but full wake survey over a plane behind any finite body should give the full drag; it is taken for granted that gas bubbles have the same drag as solid bodies in liquids (p. 329); no mention is made of possible differences in boundary conditions.

Three particular reference matters are noteworthy: (a) Prandtl makes no mention of himself (1904) as devisor of the powerful "boundary-layer theory," giving Blasius' dissertation (1908) as the first conscious work on the subject, and referring later to a free convection analysis of L. Lorenz (1881) as the earliest solution of a boundary-layer type of problem; (b) he takes considerable credit for the turbulent energy equation (1945), making no reference to Reynolds (1895) and von Kármán (1937) in this connection; (c) he explicitly declines to use the popular term "Prandtl number," pointing out that this dimensionless ratio was first devised by Nusselt. Reviewer finds this a weak excuse; one Nusselt number should be enough.

Summing up, the translation of Professor Prandtl's book stands

out among English language introductions to fluid mechanics and is recommended to everyone interested in the subject.

S. Corrsin, USA

3460. Rouse, H., and Howe, J. W., Basic mechanics of fluids, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1953, x + 245 pp. $4.50.

This elementary textbook in fluid mechanics, treated from the basic principle of kinematics and dynamics, follows the same organization of subject matter and manner of presentation as the book "Elementary mechanics of fluids" by Hunter Rouse [John Wiley & Sons, Inc., 1946]. H. G. Lew, USA

3461. Darwin, Sir Charles, Note on hydrodynamics, *Proc. Camb. phil. Soc.* **49,** part 2, 342–354, Apr. 1953.

A study is made of the actual trajectories of fluid particles in certain motions of classical hydrodynamics. When a solid body moves through an incompressible fluid, it induces a drift in the fluid such that the final positions of the particles are further on than those from which they started. The *drift-volume* enclosed between the initial and final positions is equal to the volume corresponding to *hydrodynamic mass*, that is, the mass of fluid to be added to that of the solid in calculating its kinetic energy. This result is proved quite generally. The work involves integrals which are not absolutely convergent, and these are discussed in relation to the general mechanics of fluids. When the trajectories are considered of the fluid surrounding a rotating body, it is shown that the fluid particles slowly drift round the body, even though the motion is irrotational and without circulation.

From author's summary by L. J. F. Broer, Holland

3462. Butler, S. F. J., A note on Stokes's stream function for motion with a spherical boundary, *Proc. Camb. Phil. Soc.* **49,** part 1, 169–174, Jan. 1953.

In the case of axially symmetric motion, author proves the analog of the sphere theorem of Weiss [title source, **40,** 259–261, 1944] for the Stokes stream function $\psi(r, \theta)$, r, θ, φ being spherical polar coordinates. The theorem for motion external to a sphere takes the form: If $\psi_0(r, \theta)$ is the Stokes stream function for an unbounded fluid in irrotational motion, all singularities of ψ_0 being external to $r = a$ and $\psi_0(0, \theta) = 0$, then if a rigid sphere of radius a, center at the origin, is introduced, the stream function is $\psi_0(r, \theta) - ra^{-1}\psi_0(a^2r^{-1}, \theta)$. A corresponding theorem for motion internal to a sphere is given and several applications are worked out. The proof relies on the fact that if $D\psi(r, \theta) = 0$, then $Dr\psi(a^2r^{-1}, \theta) = 0$, where

$$D = r^2\partial^2/\partial r^2 + \sin\theta(\partial/\partial\theta)[(1/\sin\theta)\partial/\partial\theta].$$

J. V. Wehausen, USA

3463. Gerber, R., On the existence of plane incompressible fluid flow which is steady, irrotational, and uniform at infinity (in French), *C. R. Acad. Sci. Paris* **235,** 25, 1601–1602, Dec. 1952.

Existence theorem for the two-dimensional irrotational flow of an incompressible nonviscous heavy fluid between a given fixed boundary extending to infinity in both directions and a free streamline, the form of the latter being unknown in advance.

J. C. Cooke, British Malaya

3464. Taylor, J. L., The potential and field of flow (induced velocity) of a plane vortex, *J. roy. aero. Soc.* **57,** 507, 179–180, Mar. 1953.

Vortex motion is briefly treated by potential theory. A derivation of the Biot-Savart law is given.

R. C. Binder, USA

3465. Pataraya, N. N., On the hydrodynamic interaction of spheres moving together in a fluid (in Russian), *Soobshch. Akad. Nauk Gruzin. SSR* **11,** 3–9, 1950.

In experiments by V. V. Shuleĭkin [Fizika morya, Moscow-Leningrad, 1941, 733–746], steel spheres, projected line abreast from the stern of a ship and cinephotographed during their sinking, were observed to draw apart as if mutually repelled. Quoting from his (unavailable) thesis [Tiflis Univ., 1948], author states expressions are derived partly theoretically and partly empirically for the hydrodynamic force on each of a system of n spheres moving line abreast. The component, in the line of centers, is for each sphere the sum of two parts, an attractive force proportional to the square of the velocity, and a force of repulsion proportional to the acceleration, so that if the spheres start with sufficiently small velocity, the repulsive force should dominate the initial stages of the motion. L. M. Milne-Thomson, England

3466. Greensmith, H. W., and Rivlin, R. S., The hydrodynamics of non-Newtonian fluids. III. The normal stress effect in high-polymer solutions, *Phil. Trans. roy. Soc. Lond.* (*A*) **245,** 899, 399–428, Jan. 1953.

Various recent experiments on flows of certain fluids, usually high polymer solutions, between rotating cylinders exhibit phenomena which the Navier-Stokes equations do not describe. In particular, the liquid climbs up the inner cylinder. Several theories have been proposed to describe this effect. The simplest and most natural is purely hydrodynamical: The viscous stresses are taken as functions of the rate of deformation only, but these functions are not linear. This theory was proposed in general terms by Reiner (1945); in the first and second paper with the same title as the present, Rivlin (1948) [AMR **2,** Rev. 1024; **3,** Rev. 912] obtained explicit and exact general solutions corresponding to the usual viscometric situations, showing that all observed effects were predicted by this theory. Weissenberg has put forward a purely elastic theory, while Garner and others have proposed more elaborate explanations of a chemical nature. There has been a rather extensive controversy on this subject. References and evaluations of some of the results of theory and experiment may be found in chap. V of the reviewer's paper [*J. rational Mech. Anal.* **1,** 125–300, 1952, additions forthcoming in **2,** no. 3].

The authors report new experiments on the torsional motion of a fluid confined between parallel plates, one of which rotates and the other is fixed. Their objective is to test the detailed quantitative predictions of the hydrodynamical theory. In their apparatus, the upper plate is the bottom of a stationary cup; the lower, the bottom of a rotating coaxial cup of greater radius, the fluid being confined between them. The pressure on the base of the stationary cup is measured manometrically by allowing the liquid to flow into small holes therein. Apparatus of similar type has been devised and employed by previous experimenters, but it is the authors' merit to have analyzed, eliminated, or corrected for sources of experimental error with extraordinary care. Three different inner cups were used, and the vertical separation of the cups was variable. Each measurement was repeated with reversed sense of rotation. The following secondary effects were taken into account: Nonparallelism of the bases, centrifugal forces, finite size of the manometric holes, tilting from the vertical, edge effects. The fluids employed were various concentrations of various polyisobutylene solutions in tetralin, at various temperatures near room temperature.

With no specialization whatever regarding the higher-order viscosity coefficients, the Reiner-Rivlin hydrodynamical theory predicts, when centrifugal effects are neglected, that the excess of the height of rise of the liquid in a manometer tube at radius r over

that at radius zero shall be a function of $r\Omega/l$ only, where Ω is the rate of rotation and l is the distance between the plates. When the measurements are adjusted to remove the effect of centrifugal forces, the authors' results confirm this prediction with great closeness. Next, the authors measure a quantity which Rivlin has called the "normal stress coefficient," which governs the quantity of the qualitative departures from the predictions of theory of linear viscosity; for the type of flow in question, Rivlin's theoretical solution predicts that this coefficient shall depend only on $r\Omega/l$, and can be determined from the above-mentioned height of rise. From their measurements, the authors conclude that for the fluids in question this function may be sufficiently approximated as linear, and they determine numerical values of the two resulting constants. They discuss also the dependence of various quantities on concentration and on temperature.

These measurements constitute a striking quantitative experimental confirmation of the results of the generalized hydrodynamical theory. C. Truesdell, USA

3467. McNown, J. S., and Newlin, J. T., Drag of spheres within cylindrical boundaries, Proc. First U. S. nat. Congr. appl. Mech., June, 1951; J. W. Edwards, Ann Arbor, Mich., 801–806, 1952.

Extension of studies to establish the influence of boundary proximity on the drag of spheres moving coaxially in a cylindrical pipe is described. Earlier work [AMR **3,** Rev. 2375] was limited by experimental techniques to Reynolds number R up to 500. The present investigation is extended to $R \approx 10^5$.

Sphere drags were not measured directly, but rather were computed from integrations of experimentally determined pressure distributions and from estimated shear drag components. From a combination of experimental and theoretical results authors present graphs showing the variation of total drag coefficients for all values of sphere-to-cylinder diameter ratios d/D between 0 and 1, and for all R from 0 to 10^5. M. S. Macovsky, USA

3468. Lewy, H., On steady free surface flow in a gravity field, *Comm. pure appl. Math.* **5,** 4, 413–414, Nov. 1952.

3469. Golubev, V. V., Investigations on the theory of a flapping wing (in Russian), *Uchen. Zap. Moskov. Gos. Univ.* **154,** *Mekh.* **4,** 3–53, 2 plates, 1951.

This summarizes the author's work on flapping wings, partially reported in *Izv. Akad. Nauk SSSR Otd. Tekh. Nauk* **1946,** 641–658, and other less accessible places. He has determined the average thrust X_0 and lift Y_0 per unit span during one period T of incompressible nonviscous plane flow about an airfoil of chord b moving forward with constant velocity V and periodically oscillating normal to V with amplitude h, frequency N, constant velocities $(-1)^j w$ $(j = 1, 2)$, and constant angles of attack θ_j relative to V. Experiments performed in 1948 by Ya. E. Polonskiĭ with such a flapping wing in a water channel suggest the following theoretical model for the flow (also described, e.g., in Durand's "Aerodynamic theory" [Springer, Berlin, 1935, v. 2, div. E, ch. V]). Vortexes of constant strength $(-1)^j\gamma$ are shed at the end of each half cycle and form a Kármán vortex street behind the airfoil of width h parallel to V, the signs of the vortex strengths being the opposite of those for a nonoscillating obstacle, however. If the transverse motion is interrupted at the end of a half cycle and continued with no change of velocity or angle of attack, then Kelvin's theorem implies that during this half cycle the circulation about the airfoil was $\Gamma_j = -\pi b\ (V^2 + w^2)^{\frac{1}{2}} \sin\ (\frac{1}{2}\ \alpha + \theta_j - (-1)^j \arctan\ w/V)$, where α depends on the airfoil's camber. Now

$$\gamma = \Gamma_2 - \Gamma_1 = 2\pi b \cos\sigma(V \sin\delta + w \cos\delta) \qquad [1]$$

where $\sigma = \alpha + \frac{1}{2}\ (\theta_1 + \theta_2)$, $\delta = \frac{1}{2}\ (\theta_1 - \theta_2)$. By the theory of vortex streets, [2] $u_0 = (\gamma/2l) \tanh\ (h\pi/l)$ where u_0 is the velocity of the vortexes, directed oppositely to V, and l is the vortex spacing in either row. For flapping airfoils $l/2h = (V + u_0)/w$, which with [1], [2], and $b/h > 0$ implies $w/V > 2h/l$.

Let x, y be a rectangular coordinate system relative to which the street's vortexes are stationary. Suppose that at some time, say $t = 0$, these vortexes are located at $\zeta_k = a + kl + \frac{1}{2}hi$ (strength γ) and $\zeta_k' = a + (\frac{1}{2} + k)l - \frac{1}{2}hi$ (strength $-\gamma$), where a, h, l are constants, and $k = 0, 1, 2, \ldots$. Let S be the rectangle with boundary L and vertexes $\pm H^{1.5} \pm Hi$, where $H^{1.5} = a + (k + 0.75)l$ for some integer k is so large that the airfoil and new vortexes that appear during $0 \leqq t \leqq T$ lie in S. Consideration of the flow of momentum through S during a period T yields

$$(Y_0 + iX_0)T/\rho = -\frac{1}{2}\int_0^T dt \int_L (dW/dz)^2 dz$$

$$- \int_L [\varphi]_0^T (dx - idy) - i\left[\iint_S (dW/dz)dxdy\right]_0^T$$

where $z = x + iy$, and $W(z, t) = \varphi + i\psi$ is the complex velocity potential. Since the only singularities of W outside of S are the street's vortexes

$$dW/dz - (\gamma/2\pi i) \sum_0^\infty [(z - \zeta_k)^{-1} - (z - \zeta_k')^{-1}]$$

$$= -u_0 + a_1/z + a_2/z^2 + \ldots \qquad [3]$$

The circulation about L yields $4\pi i a_1 = \Gamma_1 + \Gamma_2 - \gamma$, while knowledge of the forms of the coefficient $a_2, \ldots$, as functions of t is not required. By means of [3], $(Y_0 + iX_0)T$ can be evaluated to within $O(H^{-\frac{1}{2}})$, and passage to the limit $H \to \infty$ yields

$$X_0/\rho = -\gamma^2\{(h\pi/l) \tanh\ (h\pi/l) - 1\}/2\pi l - (V + u_0)\gamma h/l \qquad [4]$$

and $Y_0 = -\frac{1}{2}\ \rho\ V(\Gamma_1 + \Gamma_2)$. For $(h\pi/l) \tanh\ (h\pi/l) > \frac{1}{2}$ (or $h/l > 0.245$) $X_0 < 0$, i.e., X_0 is a thrust. If the signs of γ and u_0 are reversed, [4] reduces to Kármán's equation for the drag of a nonoscillating obstacle. The condition for stability of vortex streets $\tanh\ (h\pi/l) = 2^{-\frac{1}{2}}$ (or $h/l = 0.281$) yields $w/V > 0.562$ and

$$X_0 = -0.94\ \rho b \cos\sigma(V \sin\delta + w \cos\delta) \cdot (V + 1.2\ w)$$

For a two-dimensional flapping-wing aircraft which moves so that its altitude is periodic with period T, a motion defined as level flight, the author draws the following conclusions. A necessary and sufficient condition for level flight is $\frac{1}{2}\ (P_1 + P_2) = mg$, where $P_1(P_2)$ is the constant lift during the down-(up-)ward stroke, and mg the aircraft's weight. The mean altitude is attained at the end of each half cycle. Limitations imposed by the stalling angle of attack imply $\theta_1 < 0$ and $\theta_2 > 0$, which may account for the impression that birds in level flight seem to "row" through the air. The maximum attainable thrust

$$X_M = -(Y_{max} - Y_0)2h/l = -0.562\ (Y_{max} - Y_0)$$

where Y_{max} is the airfoil's maximum lift per unit span, and Y_0 the lift required for steady, nonflapping level flight. Finally, the author considers numerical examples which give reasonable agreement with observed values of V, h, and N for level flight of doves and flies, and which account for a certain unsuccessful ornithcopter's failure to fly. J. H. Giese, USA

3470. Golubev, V. V., On some questions of the theory of a flapping wing (in Russian), *Uchen. Zap. Moskov. Gos. Univ.* **152,** *Mekh.* **3,** 3–12, 1951.

This treats the case $V = 0$, $\alpha = 0$ (symmetrical airfoil), $\theta_1 = -\theta_2$ of the preceding paper for application to the hovering flight of birds in which the body is roughly vertical and the wings flap more or less horizontally. The spacing $l = h/0.281$ and velocity $u_0 = \gamma/2^{1.5}l$ of the vortex street and $N = u_0/l$ yield $h = w/2N = 0.34b\cos\theta_1$. Also $X_3/b = P/S$ yields $N^2 = P\lambda/(0.57\rho S^2\cos^3\theta_1)$, where P grams is the bird's weight, and S cm² and $\lambda = S/b^2$ are the wing's area and aspect ratio. For hummingbirds (sea gulls) an empirical formula $S^{1/2}P^{-1/4} = 4.2$ and assumptions $1 < \lambda < 2$ ($\lambda = 7.6$), and $30° < \theta_1 + 90° < 45°$ yield computed frequencies from about two to five (one to three) times the observed values. J. H. Giese, USA

3471. Reid, E. G., Performance characteristics of plane-wall two-dimensional diffusers, *NACA TN* 2888, 80 pp., Feb. 1953.

Incompressible-flow tests were performed on a two-dimensional diffuser with a variation of the wall angle from 3° to 19° and a variation of exit area to inlet area of 2 to 5. The majority of tests were performed with the flow being discharged into a large chamber, but a few tests were performed with the flow being discharged into a rectangular duct. Stagnation pressures were measured at the inlet and outlet sections. Piezometric pressures were measured along the divergent walls. The thickness of the initial boundary layer was stabilized by performing all tests at an identical inlet Reynolds number. In addition, the initial boundary layer was made turbulent by means of roughness in the bellmouth entrance. Values of the pressure-recovery coefficient (the ratio of the difference of exit and inlet piezometric pressure to the inlet kinetic energy) are presented as a function of the geometric variables. Volumetric efficiencies (defined in the same manner as the formerly used coefficient of velocity of hydraulics) are presented as a function of the geometric variables. The geometrical limits for steady flow within the diffuser were determined.

Reviewer believes that the omission of detailed analysis of the exit velocity distributions unnecessarily restricts the scope of the work. In many diffusers, such as highway box-culvert outlets, the attainment of a uniform velocity distribution is of greater importance than a high value of energy efficiency.

M. R. Carstens, USA

3472. Shu, S. S., Note on the collapse of a spherical cavity in a viscous incompressible fluid, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 823–825, 1952.

Mathematical proof, based on the theory of nonlinear differential equations, that a spherical cavity in a viscous, incompressible liquid will not collapse if the dimensionless quantity $\mu/R\rho^{1/2}p^{1/2}$ (μ viscosity, R radius of the cavity, ρ density, p pressure difference between cavity and infinity) exceeds a certain value, of the order 0.5. Surface tension is neglected. It is asserted that its introduction will always lead to collapse.

H. C. Brinkman, Indonesia

3473. Birkhoff, G., Induced mass with variable density, *Quart. appl. Math.* **11,** 1, 109–110, Apr. 1953.

Note represents extension of author's previous [AMR **5,** Rev. 3134] concept of induced mass, and some of its properties to the case of an incompressible fluid of variable density. Proofs parallel closely those given before for case of free boundaries. Following are proved: Acceleration kinetic energy is minimized, relative to all other volume conserving flows satisfying the condition of normal acceleration; diagonal components of induced mass are increased, if the fluid density is increased in any region and left unchanged elsewhere; and two theorems on tensor component and liquid momentum. No applications are discussed.

M. Z. Krzywoblocki, USA

Compressible Flow, Gas Dynamics

(See also Revs. 3459, 3498, 3499, 3501, 3530)

3474. Morikawa, G., Conical potential solutions in linearized supersonic flow, *J. aero. Sci.* **20,** 4, 283–285, Apr. 1953.

An important concept in the development of linearized supersonic flow theory is the conical flow theory originated by Buseman, wherein conical boundary-value problems are considered in which the velocity components are conical. Attention is focused in this paper on strip-type boundary-value problems in which the potential itself is conical. In application, conical potential solutions are useful in the calculation of spanwise and chordwise lift distributions of twisted wings.

From author's summary by K. C. Harder, USA

3475. Wasserman, L. S., The equations for pressure and momentum using linearized theory for compressible flow, *J. aero. Sci.* **20,** 3, p. 210, Mar. 1953.

Note in Readers' Forum.

3476. Giese, J. H., and Cohn, H., Two new non-linearized conical flows, *Quart. appl. Math.* **11,** 1, 101–108, Apr. 1953.

Two supersonic flows with plane boundaries are constructed by piecing together conical waves, three-dimensional flows with less-than-three-dimensional hodographs and with constant properties along rays through a vertex. One case gives the flow over a dihedral angle with supersonic leading edges at moderate angles of attack, the other a simpler flow formed when a wedge of proper shape is symmetrically placed in the dihedral. Methods for calculating flow parameters are indicated. C. M. Ablow, USA

3477. Ferri, A., Conical flow without axial symmetry, *Aerotecnica* **33,** 1, 69–71, Feb. 1953.

Excerpt from a previous paper with application to elliptical cones. See AMR **5,** Rev. 1137. G. Guderley, USA

3478. Chang, C.-C., and O'Brien, V., Some exact solutions of two-dimensional flows of compressible fluid with hodograph method, *NACA TN* 2885, 63 pp., Feb. 1953.

Much insight into the mechanism of the theory of compressible potential flows is presented. Several useful solutions are presented and analyzed. A new scheme for classifying compressible potential flows is presented. K. M. Siegel, USA

3479. Gullstrand, T. R., A theoretical discussion of some properties of transonic flow over two-dimensional symmetrical aerofoils at zero lift with a simple method to estimate the flow properties, *Roy. Inst. Technol. Div. Aero., Stockholm, KTH-Aero TN* 25, 20 pp., June 1952.

Speed and mass flow density in Oswatitsch's transonic integral equation [AMR **4,** Rev. 302; see also K. Oswatitsch, "Gasdynamik," Springer, Wien, 1952, p. 362 ff] are expanded under the assumption $|1 - M_\infty| << |1 - M|$ on and in the vicinity of the airfoil. The resulting integral equation seems only weakly to depend on M_∞ so that in a certain "sonic range" about $M_\infty = 1$, the M-distribution on the airfoil is independent of M_∞. Using this and his earlier results [AMR **5,** Rev. 1472; **6,** Rev. 1970], author discusses properties of the M-distribution such as: Existence of a velocity maximum ahead of the shock *on* the airfoil;

failure of the transonic similarity law if the *positions* of the shock *on* airfoils with different thicknesses are compared; M-values of trailing edge and thickness maximum in and outside the "sonic range"; position of the bow wave; M-distribution for $M_\infty = 1$. The simple method (title) applies to very thin airfoils and presupposes knowledge of the results for $M_\infty = 1$.

G. Kuerti, USA

3480. Morawetz, C. S., and Kolodner, I. I., On the nonexistence of limiting lines in transonic flows, *Comm. pure appl. Math.* **6,** 1, 97–102, Feb. 1953.

Friedricks' statement that limiting lines cannot appear in analytic mixed flows which depend continuously on Mach number (like flow on fixed airfoil with bounded supersonic region) is here given new proof, which dispenses with condition of analyticity and requires only continuous second derivatives. If profile changes continuously with changing Mach number, limiting line can appear only with infinite curvature of profile.

L. Crocco, USA

3481. Johnston, G. W., An investigation of the flow about cones and wedges at and beyond the critical angle, *Univ. Toronto, Inst. Aerophys., Rep.* no. 24, 33 pp., 31 figs., Dec. 1952.

Author presents results of experiments in the Institute of Aerophysics' 16 × 16-in. supersonic tunnel at $M = 2.65$, which determine the nature of the subsonic flow field behind detached bow waves produced by wedge and cone models at zero angle of attack. Results include (1) lateral and forward extent and growth of this subsonic field as detachment proceeds determined by schlieren and shadow photographs, and (2) pressure distributions measured over the surface of the model. Forebody pressure drag of cones and wedges with a detached wave is determined from these pressure measurements. A hodograph solution for the flow field behind a detached wave associated with a wedge is presented, and calculated results indicate good agreement with experiment.

R. E. Bolz, USA

3482. Travers, S., Limitation of gradients and their logarithmic derivative in shock waves, by the Chapman formulas (in French), *C. R. Acad. Sci. Paris* **235,** 19, 1099–1101, Nov. 1952.

"Continuous" analysis of inner structure of very strong shock waves needs to take into account the thermal conduction and stresses depending on first and second derivatives of velocity and temperature, according to the results of kinetic theory of nonuniform gases (Chapman). Relative importance of every derivative is pointed out by limitation of the first in point of maximum gradient, and of the second in front of the wave, considering both as functions of mean free path and mean quadratic velocity.

G. Moretti, Argentina

3483. Kuo, Y-H., Reflection of weak shock wave from a boundary layer along a flat plate. II. Interaction of oblique shock wave with a laminar boundary layer analyzed by differential-equation method, *NACA TN* 2869, 60 pp., Jan. 1953.

The resulting interaction when an oblique shock wave in a steady, compressible, viscous supersonic stream is incident upon an insulated, flat plate is studied for the case of small free-stream Mach numbers where the shock strength and angle of incidence is such that regular reflection occurs. It is assumed that the viscosity and thermal conductivity of the gas may be considered constant throughout the field, and the Prandtl number taken as unity.

By analogy with the boundary-layer concept, the field is divided into two regimes—a large outer field characterized as potential (and irrotational), and a much smaller inner field assumed predominantly viscous. By reference to experimental observations (and the occurrence of back flow), the assumption is made that the viscous region may be subdivided into two regimes; one, an outer sublayer wherein the flow is compressible (viscous and inertia terms being important), and the other, an inner sublayer (adjacent to the plate) of incompressible fluid.

The general equations of conservation of mass, momentum, and energy, with viscous terms included, are written for the two-dimensional flow case in terms of nondimensional quantities and are assumed applicable to the inner viscous part of the field; the general, two-dimensional, compressible, potential equation is assumed descriptive of the outer flow field. The outer and inner flow regimes are assumed to join smoothly, subject to the boundary conditions of no slip flow at the plate, and that, at an infinite distance from the plate, the velocity assumes the potential value. Solutions are assumed expandable in terms of ϵ, the flow deflection through the shock, in the form

$$u = u^{(0)} + \epsilon^1 u^{(1)} + \epsilon^2 u^{(2)} + \epsilon^3 u^{(3)} + \ldots\ldots\ldots\ldots \text{etc.}$$

similar expressions applying for v, p, ρ, and T. By substitution, systems of equations are written for zero-order, first-order, and second-order flow systems, respectively.

Solutions to the first-order system of equations for the flow upstream from the incident shock are obtained by making the general assumption in the viscous flow region, that the derivatives of the basic flow parallel to the plate are negligible in comparison to derivatives taken normal to the surface, and that the zero-order velocity component in the normal direction is zero. In the incompressible sublayers, a linear velocity profile is assumed, and the solutions to the equations in this case presented in a form involving Bessel functions of the first and second kind with imaginary arguments. In the compressible sublayer, the general equations are reduced by assuming the zero-order velocity component parallel to the wall, and the zero-order density to be equal to the free-stream velocity and density at infinity, respectively. By assuming the first-order enthalpy term to be zero, a solution to the system of equations of the compressible sublayer is presented. The eigenvalues and undetermined constants involved in the resulting solutions to the equations of the two viscous sublayers are determined by applying the conditions of continuity of pressure and velocity across their interface and obtaining a set of simultaneous equations for the undetermined constants; the eigenvalues are determined by setting up the necessary and sufficient condition for a nontrivial solution. The complexity of the ensuing determinant renders the problem mathematically intractable, and the author resorts to numerical solutions.

As a result of this first-order solution upstream from the incident shock, the author finds that: (1) The pressure decays exponentially forward from the point of incidence; (2) the distance of forward pressure propagation decreases with increases in both Mach number and Reynolds number (varying according to the relation $\{(M^2 - 1)^{1/2} R\}^{-3/4}$, where M is the Mach number and R the Reynolds number) and varies only slightly with shock strength; (3) for strong enough shock strengths, separation of the flow will always occur, the pressure at the point of separation being proportional to $\{(M^2 - 1)^{1/2} R\}^{-1/2}$.

A potential solution to the first-order system of equations for the flow downstream from the incident shock is obtained by perturbation of weak incident waves. To obtain a potential solution downstream from the reflected wave, it is noted that the condition that the viscous layer joins smoothly with the potential field and that the pressure and velocity remain continuous at the point of incidence demands a discontinuous expansion. Some simple solutions of the viscous equations satisfying the boundary conditions are presented and discussed; it is concluded that, in the viscous

layer, transition from laminar flow will always occur regardless of incident shock strength.

A flow field, in agreement with experimental observations, is constructed in accordance with first-order theory. Upstream from the point of incidence of the shock, the viscous layer thickens appreciably, causing positive curvature of the streamlines and a compression wave. At the point of incidence, a centered type of expansion wave occurs (associated with transition), while downstream from the incident shock, the curvature of the streamlines is again positive and the Mach waves in the potential field must coalesce to form a shock which approaches asymptotically the regularly reflected shock in an inviscid fluid.

Reviewer feels this paper to be a valuable addition to the subject of shock-wave boundary-layer interactions.

G. V. Bull, Canada

3484. Kofink, W., and Vollmer, Th., Three-shock configurations in air (in German), *ZAMM* **33,** 3, 73–88, Mar. 1953.

This is a sequel to an earlier paper [AMR **5,** Rev. 2660] and gives numerical results for certain critical and limiting situations. It also includes an algebraic analysis of the method of using diagrams of pressure-ratio vs. stream-deviation (p, θ diagrams) for the study of three-shock configurations.

D. C. Pack, England

3485. Gontier, G., Experimental determination of the transonic flow of a nozzle under two-dimensional flow conditions (in French), *Rech. aéro.* no. 31, 13–19, Jan.-Feb. 1953.

P. Germain [AMR **6,** Rev. 1808] has studied two-dimensional flows which pass from subsonic to supersonic conditions. The sonic line separates the different regions. Upon studies of the governing mixed-type differential equations, Germain introduced a new line, the sonic front, which lies in the supersonic region. The region between sonic line and sonic front is called transonic, because disturbances in this region should be felt in the subsonic region. Gontier studied such flows experimentally by introducing a small disturbance in the different regions of the flow field. He found that the "transonic region" is existent and that its flow field is single-valued.

The paper contains a detailed description of the development of an indented rod which had to produce the disturbance. It was found easier to produce an expansion than a compression disturbance.

I. Flügge-Lotz, USA

3486. Gilbarg, D., Comparison methods in the theory of subsonic flows, *J. rational Mech. Analysis* **2,** 2, 233–251, 1953.

Comparison methods applied previously by author and others to problems in incompressible flow are applied to subsonic compressible flows for which the maximum local Mach number is less than unity. Paper includes proofs of monotonic dependence of boundary-flow speed on free-stream velocity in plane and axisymmetrical flows past walls and symmetrical bodies and through channels, also proofs of uniqueness with respect to free-stream Mach number and maximum local Mach number. Power of comparison method in applications to this kind of nonlinear flow problem is ably demonstrated.

G. N. Ward, England

3487. Mayhew, Y. R., and Roger, G. F. C., One-dimensional irreversible gas flow in nozzles, *Engineering* **175,** 4547, 355–358, Mar. 1953.

To take account of viscosity in a modified one-dimensional theory of nozzle flow, authors introduce a tangential shear force along the nozzle walls. The presence of this prevents the attainment of critical conditions at the throat, and, in general, flow is nonisentropic, with critical section just downstream of the throat.

Maurice Holt, England

3488. Scheller, K., and Bierlein, J. A., Some experiments on flow separation in rocket nozzles, *J. Amer. Rocket Soc.* **23,** 1, 28–32, 40, Jan.-Feb. 1953.

Flow separation in de Laval nozzles has been investigated experimentally over a range of divergence angles and reservoir pressures using compressed air as a working fluid. The results indicate that the onset of separation in such nozzles is governed primarily by the reservoir pressure and the nozzle divergence angle. However, no quantitative treatment has been evolved to unify all the existing experimental data. Further experimental work, or a more sophisticated interpretation of available facts, is needed to establish a theory for predicting the plane of separation for a nozzle of given geometry operated under specified conditions.

From authors' summary by J. V. Becker, USA

3489. Allen, H. J., The asymmetric adjustable supersonic nozzle for wind-tunnel application, *NACA TN* 2919, 30 pp., Mar. 1953.

Report evaluates advantages and disadvantages of the fixed and adjustable geometry types of supersonic nozzles which are currently in use in wind tunnels. The economic and mechanical disadvantages encountered with these conventional nozzles in achieving a continuously variable range of Mach numbers have led to the development of the plug- or spike-type nozzle. This nozzle theoretically achieves the desired Mach number range by moving the plug into a predetermined channel, thereby reducing the throat and achieving the required area ratio.

Author presents experimental evidence that the shock and wake system introduced into the test section makes the two-dimensional plug nozzle impractical for testing purposes. An evolutionary form (one half of a two-dimensional plug nozzle), the asymmetrical adjustable supersonic nozzle eliminated the wake and shock system. (The theoretical basis for calculating the coordinates are given in *NACA TN* 2922 and 2921.) Schlieren photographs and Mach number surveys show that very good flow may be achieved over the nominal range $M = 0.9$ to 2.0. These tests were conducted in 1.5×1.5-in.^{2} and 8×8-in.^{2} test sections, which served as pilot tunnels for the 6×6-ft^2 tunnel to be constructed at the Ames Laboratory.

Author points out that the asymmetric nozzle suffers from thick boundary layers on the convex surface, separations at higher Mach numbers ($M > 2.5$, say), pressure gradients at some Mach numbers, and larger power requirements. Reviewer agrees that these faults may be overcome with boundary-layer control and improved nozzle-diffuser design for this type of installation. It would be worth while to install a nozzle of this type in a blowdown tunnel in order to test the maximum Mach number that may be achieved. Reviewer believes that this type of nozzle is a definite contribution to the development and operation of supersonic wind tunnels.

I. I. Glass, Canada

3490. Hansen, A. G., Herzig, H. Z., and Costello, G. R., A visualization study of secondary flows in cascades, *NACA TN* 2947, 93 pp., May 1953.

Secondary (nonpotential) flows in cascades were studied using three visual techniques. At low speed, smoke was introduced through static pressure taps or a traversing probe. At higher speeds, hydrogen sulfide gas reacted with a lead-carbonate coating to produce flow traces on blades and walls. Also at high speeds, a nondrying paint was used to show flow patterns. Report contains numerous photographs showing the patterns made visible by these methods. The models included a basic two-dimensional cascade with modifications to show tip-clearance effects with stationary or moving wall (flow speeds to $M = 0.4$); an annular-turbine-nozzle cascade (run at high subsonic and supersonic tip

speeds); rectangular bends, high-turning cascades, and a tandem cascade. The results permitted observation of the formation of a vortex due to end-wall boundary layer, and a tip-clearance vortex.
L. H. Schindel, USA

3491. Rao, G. V. R., Compressible flow past a cascade of thin airfoils, *J. aero. Sci.* **20,** 3, 217–218, Mar. 1953.

The linearized method by Pistolesi for calculation of flow through a cascade of thin airfoils is extended to compressible flow. As a result of the calculation, the difference between the perturbation velocity on the airfoil in the cascade and on an isolated airfoil is obtained. Spurr and Allen used a different approach and found that the interference effect of the airfoils in the cascade results in a decrease of the lift-curve slope for high solidities with increasing Mach number. The present calculation does not show such an adverse effect. E. R. G. Eckert, USA

3492. Zvereva, K. D., Determination of the aerodynamic moment exerted upon a wing by a compressible fluid in the case of plane steady flow (in Russian), *Uchen. Zap. Moskov. Gos. Univ.* **152,** *Mekh.* **3,** 187–201, 1951.

3493. McLafferty, G., Theoretical pressure recovery through a normal shock in a duct with initial boundary layer, *J. aero. Sci.* **20,** 3, 169–174, Mar. 1953.

Author assumes various initial velocity profiles in a duct corresponding to supersonic flow with turbulent boundary layers, and computes pressure recovery resulting in transition to a subsonic flow with velocity uniform across the duct, assuming conservation of momentum and mass. The pressure recovery is expressed in ratio to the pressure recovery which would have resulted if the initial flow had been uniform and pressure recovery had been effected by a normal shock. The results show that this ratio is approximately proportional to displacement thickness of the initial boundary layer, and nearly independent of Mach number in the free stream before the transition. The effect of wall friction during the transition is considered, and some comments are also made on removal of the boundary layer and its effect on pressure recovery. The results of the analysis are primarily important in predicting operating characteristics of supersonic diffusers and power requirements in wind tunnels, and show that the pressure recovery for a nonuniform stream is appreciably less than that in a one-dimensional flow with normal shock.
E. W. Price, USA

3494. Slezkin, N. A., On the impact of a plane gas jet on an infinite wall (in Russian), *Prikl. Mat. Mekh.* **16,** 2, 227–230, Mar.-Apr. 1952.

Short recapitulation of results obtained previously by Chaplígin, Joukowsky, and Schach. E. Krahn, England

3495. Bruce, G. H., Peaceman, D. W., Rachford, H. H., Jr., and Rice, J. D., Calculations of unsteady-state gas flow through porous media, *J. Petr. Technol.* **5,** 3, 79–92, Mar. 1953.

The problem of unsteady-state gas flow through porous media leads to a second-order nonlinear partial-differential equation for which no analytical solution has been found. In this paper, a stable numerical procedure is developed for solving the equation for production of gas at constant rate from linear and radial systems. An electronic digital computer is used to perform the numerical integration using an implicit form of an approximating difference equation. Solutions are presented in graphical form for various values of dimensionless parameters. The solutions are compared with the laboratory study of gas depletion in a linear system. L. M. Milne-Thomson, England

Turbulence, Boundary Layer, etc.

(See also Revs. 3467, 3493)

3496. Lin, C. C., A simplified formulation of the similarity concepts in isotropic turbulence, *J. aero. Sci.* **20,** 4, p. 286, Apr. 1953.

Author establishes cases of self-preservation in isotropic turbulence from dimensional arguments. Strict self-preservation is shown to be impossible. Three approximate cases previously recognized are obtained and other possibilities are indicated.
W. DeLapp, USA

3497. Frenkiel, F. N., Turbulent diffusion from a non-punctual source, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 837–841, 1952.

Using the conventional analysis for diffusion of a single particle in isotropic turbulence, author derives the distribution of mean concentration of marked fluid for the case in which the marked fluid initially occupies a sphere.
G. K. Batchelor, England

3498. Krzywoblocki, M. Z. E., On the equations of isotropic turbulence in magneto-hydrodynamics of compressible medium, *Acta Phys. Austr.* **6,** 157–166, 1952.

The invariant theory of isotropic turbulence in an incompressible fluid and in the framework of magneto-hydrodynamics developed by the reviewer [*Proc. roy. Soc. Lond.* (*A*) **204,** 435–449, 1951] is extended to the case of a compressible fluid. Thus instead of defining $\overline{u_i u_j'}$ and $\overline{u_i h_j'}$, one defines $\overline{\rho u_i \rho' u_j'}$ and $\overline{\rho u_i h_j'}$ in the compressible case; for, in this way, the solenoidal character of the tensors is preserved. With this redefinition of the tensors, the theory proceeds as in the incompressible case with no essentially novel features.
Courtesy of Mathematical Reviews S. Chandrasekhar, USA

3499. Watson, E. J., The asymptotic theory of boundary-layer flow with suction, *Aero. Res. Counc. Lond. Rep. Mem.* 2619, 45 pp., Sept. 1947, published 1952.

An analytical study has been made of the steady two-dimensional boundary layer flowing over a permeable surface through which the fluid is withdrawn at a known rate of suction.

Assuming initial approximations to the boundary-layer thickness, the velocity distribution in the boundary layer, and to the skin friction, a method of successive approximations leads to a series in inverse powers of the suction velocity. This series formally satisfies the boundary-layer equations and represents either an exact or an asymptotic solution for large values of the suction velocity. The cases of similar velocity distributions, ot uniform suction velocity, and the general case of arbitrary distributions of both the free-stream and the suction velocities are dealt with.

Expressions for the skin friction and for the displacement and momentum thicknesses are derived, and the suction velocity necessary to prevent flow separation is predicted.

Numerical results are derived for many various suction velocities and are given in both tabular and graphical form. In the simpler cases of uniform suction velocity, the method is applied to the boundary layer over a circular cylinder and two different airfoils, and the singularities which restrict the use of the method are discussed. At many points, comparison is made with previous work along similar lines, but there is no comparison with experimental results. The latter would be helpful.
Ione D. V. Faro, USA

3500. Klunker, E. B., and McLean, F. E., Effect of thermal properties on laminar-boundary-layer characteristics, *NACA TN* 2916, 29 pp., Mar. 1953.

An iteration method is presented for solving the laminar-boundary-layer equations for compressible flow in the absence of a pressure gradient wherein the temperature variation of all the fluid thermal properties is considered. Friction and heat-transfer characteristics have been calculated for a stream temperature of −67 F for Mach numbers from 1 to 10, with the use of values of the heat capacity, conductivity, and viscosity determined from experiment. Consideration of the temperature variation of all the fluid thermal properties causes the recovery factor to decrease substantially with increasing Mach number. Moreover, the heat-transfer rate is found to be proportional to the difference between an effective enthalpy, which is a function of both the surface temperature and stream Mach number, and the surface enthalpy. In contrast, the heat-transfer rate is approximately proportional to the difference between the recovery enthalpy and the surface enthalpy for solutions which employ a constant Prandtl number. The calculated skin-friction and heat-transfer rates based upon the use of the Sutherland equation for viscosity and a Prandtl number of 0.75, however, are in excellent agreement with the results of the present analysis.

From authors' summary by R. M. Drake, Jr., USA

3501. Probstein, R. F., and Lees, L., On the recovery factor for hypersonic flow with a self-induced pressure gradient, *J. aero. Sci.* **20,** 4, 291–292, Apr. 1953.

Paper gives in closed form the first approximation for the wall temperature in hypersonic flow with a self-induced pressure gradient due to the laminar boundary layer. The equilibrium wall temperature has exactly the same value as for zero pressure gradient. Thus Busemann's conclusion that the recovery temperature is unaffected by pressure gradient for $Pr = 1$ is generalized to arbitrary Pr, at least for the case of weak interaction in hypersonic flow. T. R. Gullstrand, Sweden

3502. Dienemann, W., Calculation of the thermal boundary layer of the flow around bodies with constant and variable wall temperature (in German), *ZAMM* **33,** 3, 89–109, Mar. 1953.

Author presents an approximate method for calculating the growth of the thermal boundary layer in two-dimensional laminar flow. The method is strictly analogous to that of K. Pohlhausen for the flow boundary layer, and bears much similarity to those of Eckert, Frössling, and Kroujiline devised for the same purpose. Besides useful graphs and tables, paper also contains examples, including one illustrating the extended application of the method to the thermal boundary layer of a yawed wing. Whereas comparison of results obtained by the present method to those obtained by the methods of previous investigators shows only slight deviations, author claims the present method is much more convenient for calculations. C.-S. Yih, USA

3503. Oudart, A., Investigation of the boundary layer of a flat plate starting motion suddenly from rest (in French), *Rech. aéro.* no. 31, 7–12, Jan.-Feb. 1953.

Author investigates the unsteady boundary layer on a flat plate which is suddenly set into uniform motion. He uses the von Kármán-Pohlhausen method, assuming final velocity profiles of the Blasius form for the laminar case and profiles of the $^1/_7$ power law for the turbulent case. A finite time interval is required to reach the steady case. The investigation is also extended to thermal boundary layers. W. Wuest, Germany

3504. Mager, A., Mahoney, J. J., and Budinger, R. E., Discussion of boundary-layer characteristics near the wall of an axial-flow compressor, *NACA Rep.* 1085, 20 pp., 1952.

The boundary-layer velocity profiles in the tip region of a single-stage axial-flow compressor downstream of the guide vanes and downstream of the rotor were measured by use of total-pressure and claw-type yaw probes. These velocities were resolved into two components: one along the streamline of the flow outside the boundary layer, and the other perpendicular to it. An affinity among all profiles was demonstrated, with the boundary-layer thickness and the deflection of the boundary layer at the wall as the generalizing parameters.

The important parameters concerning the secondary flow in the boundary layer are shown to be the turning of the flow and the product of the curvature of the streamline outside the boundary layer and the boundary-layer thickness.

The losses near the tip of the rotor blades and near the hub of the stator blades are traced to the predominantly tangential direction of the flow in the boundary layer. It is demonstrated that at large turnings the flow does not necessarily part with the surface when a separated axial-velocity profile is present.

J. V. Becker, USA

3505. Rubesin, M. W., A modified Reynolds analogy for the compressible turbulent boundary layer on a flat plate, *NACA TN* 2917, 23 pp., Mar. 1953.

The relationship between heat transfer and skin friction is reexamined to include the effects of compressibility and the consequent relative thickening of the laminar sublayer and the buffer layer. The effects of frictional dissipation and of the differences in the turbulent exchange mechanism of momentum and heat are emphasized. One of the basic assumptions used in the study is that the ratio of the thermal energy flux to the shear stress remains constant through the boundary layer. The author admits that such an assumption is "arbitrary, but plausible." Using the Frankl and Voishel expression for the velocity ratio, it is shown that the ratio of the Stanton number to half the local skin-friction coefficient varies from 1.18 to 1.21 for both the incompressible case and for values of Mach number up to 5. The well-known Reynolds analogy based on simpler assumptions gave the ratio as unity. Ione D. V. Faro, USA

Aerodynamics of Flight; Wind Forces

3506. Legendre, R., Vortex flow around the leading edge of airfoils at moderate angles of incidence, I, II (in French), *Rech. aéro.* nos. 30, 31; 3–8, 3–6, Nov.-Dec. 1952; Jan.-Feb. 1953.

Principles of theoretical analysis are presented for subsonic field of flow generated by delta wing at high incidence, which has been found experimentally [Maurice Roy, *C.R. Acad. Sci. Paris* **234,** no. 26, p. 159] to involve a pair of conical free-vortex sheets above suction side, connecting up with swept leading edges. Analysis is based on slender-body theory. Replacing vortex sheets by two concentrated downstream intensifying vortexes issuing from apex of wing, equilibrium configurations are determined and shown to be stable with respect to symmetrical perturbations. Calculated life of wing is nonlinear with incidence and shows questionable anomalies at small incidence and surpasses the conventionally calculated values at high incidence. No comparisons with measurements are presented; results are said to be not entirely satisfactory.

In second part, attempt is made to prevent substitution of concentrated vortexes for vortex sheets. Analysis leads to integro-differential equation which, however, does not seem to be satis-

factorily defined, and of which no solutions are presented. Much additional work will be required to evaluate this definitely interesting layout of extended delta-wing theory.

J. H. Greidanus, Holland

3507. Lawrence, H. R., The pressure distribution on low aspect ratio wings in steady or unsteady incompressible flow, *J. aero. Sci.* **20,** 3, 218–219, Mar. 1953.

Note extends results of previous papers by the author and others [see AMR **5,** Rev. 3147; AMR **6,** Rev. 534] to include a brief physical explanation of mathematical procedures and a computational method for the distribution of pressure on low-aspect-ratio wings in incompressible flow.

Assumptions for the induced angle-of-attack distribution used in the evaluation of the velocity potential are similar to the Prandtl and Weissinger assumptions for the symmetric and unsymmetric spanwise-lift distributions, respectively.

J. B. Duke, USA

3508. Keune, F., Low aspect ratio wings with small thickness at zero lift in subsonic and supersonic flow, *Roy. Inst. Technol., Div. Aero., KTH-AERO TN* 21, 57 pp., 1952.

This paper is concerned with the determination of the theoretical velocity and potential fields for the flow about low-aspect-ratio wings and slender bodies. The analysis starts with the linearized theory expressions for subsonic and supersonic source distributions and proceeds by introducing the appropriate simplifications permissible with slender wings and bodies. It is shown that the disturbance field, in both subsonic and supersonic flight, consists of two-dimensional disturbance fields extending laterally and a longitudinal field that depends on the streamwise growth of cross-section area. (The reviewer notes that these results and those of *NACA TN* 2900 are mutually supplementary.) The results of a number of specific applications to bodies of revolution and to wings of triangular or rectangular planform are included in both analytical and grahical form and compared with the corresponding results obtained without introducing the slenderness restrictions.

J. R. Spreiter, USA

3509. Loos, H. G., and Zwaaneveld, J., Secondary flow in cascades, *J. aero. Sci.* **19,** 9, 646–647, Sept. 1952.

Note discusses discrepancies in adding of the trailing vortexes, which appear in reports by J. M. Stephenson, [AMR **5,** Rev. 2407] and H. P. Eichenbrenner [title source, **19,** 2, 137, Feb. 1952]. Authors give a method of determination, using Hawthorne's relation [AMR **4,** Rev. 3607]. Results correspond with Squire and Winter [AMR **4,** Rev. 3672] or with Stephenson's cascade [Rev. cited].

F. Kuene, Sweden

3510. Dannenberg, R. E., and Weiberg, J. A., Section characteristics of a 10.5-percent-thick airfoil with area suction as affected by chordwise distribution of permeability, *NACA TN* 2847, 52 pp., Dec. 1952.

This investigation on the effect of leading-edge suction included measurements of pressure distribution, momentum drag, boundary-layer characteristics, and flow resistance of granular, fibrous, and perforated types of porous substances. Two procedures were used in the primary testing. Fixed minimum suction at points of external minimum pressure was maintained while varying the angle of attack, and minimum suction speed at minimum pressure points was varied at fixed angles of attack.

Lift-coefficient increases of 31 to 37% were obtained with c_q's of 0.0008 and 0.0014, respectively. The results appear to confirm the Thwaites theory, which indicates that the distance over which the suction should be applied need extend only to the chordwise station at which the adverse velocity gradient at a given lift coefficient is no more severe than the maximum velocity gradient on the wing prior to stall in the absence of suction. The suction was also found to produce forward movement of the stagnation point. Comparisons with calculated distribution on a Joukowsky airfoil indicated that above 12° angle of attack, suction placed the stagnation point as predicted by theory. Chordwise variations in permeability (decreasing downstream) of the porous surface were very important and brought about reductions in suction flow and power required.

M. G. Scherberg, USA

3511. Rose, R. G., A note on the estimation of some low speed characteristics of delta wings, *Coll. Aero. Cranfield Rep.* 68, 16 pp., 14 figs., Jan., 1953.

Paper deals with calculation of low-speed characteristics of delta wings by means of the swept lifting-line theory developed by Weissinger. Planforms considered include the conventional delta or triangular wings with straight trailing edge, as well as those with tips cropped off parallel to axis of symmetry.

Characteristics determined include lift-curve slope at zero lift, location of aerodynamic center, and estimates of maximum lift coefficient and stalling angle, all for symmetrical loadings. For the unsymmetrical cases, rolling and yawing characteristics at low angles of attack are computed.

Comparisons are made with other theories and with experimental results.

M. J. Thompson, USA

3512. Eula, A., On the calculation of the drag of rectangular wings at supersonic speeds (in Italian), *Aerotecnica* **33,** 1, 54–64, Feb. 1953.

Linearized theory is used to calculate the drag due to thickness for two families of wings. Both of them have a linear variation in the spanwise direction of the maximum profile thickness, the thickness being zero at the tips. One family has symmetric double-wedge profiles. The profiles of the other family have a section of constant thickness between a leading and a trailing wedge, the boundaries between those parts being the diagonal of the wing planform.

S. B. Berndt, Sweden

3513. Lawrence, T., Charts of the wave drag of wings at zero lift, *Aero. Res. Counc. Lond. curr. Pap.* 116, 10 pp., 9 figs., 1953.

Available numerical evaluations of zero-lift wave drag from supersonic thin-wing theory are gathered, compared, and presented in a systematic graphical form. Thought is given to the best method of presenting results considered (an example which many other compilers of engineering data would do well to emulate). Charts are basically plots of C_D vs. M for various combinations of sweep and aspect ratio, with separate diagrams for each combination of taper ratio and position of maximum thickness of double-wedge section considered. Case of biconvex section, zero taper also is plotted.

Report is a boon to practicing aerodynamicist for rapid estimation of supersonic wing drag.

J. S. Isenberg, USA

3514. Jacobs, W., Experimental investigations on sheared wings (in German), *Ing.-Arch.* **20,** 6, 418–426, 1952.

Paper gives results from experiments made during 1944 in Braunschweig, Germany. To check the cosine law for swept wings, forces and pressure distributions on three sheared wings ($\varphi = 0°, 30°, 45°$) with end plates are measured at low speed. Reasonable agreement is obtained. Results from measurements without end plates are also given.

T. R. Gullstrand, Sweden

3515. Kleinhenz, F., Analysis and design of a wind wheel of 130-m diameter (in German), *Stahlbau* **22**, 3, 49–56, Mar. 1953.

A four-bladed propeller is chosen using an NACA 23015 airfoil section. The main structural element for each blade is a tapered steel beam of pipe form which runs the length of the blade and is placed at the quarter-chord point of each section. The blade section is formed of thin steel plates supported on ribs from the pipe beam.

The useful power generated is estimated from the formula $N = 0.00018V^3D^2$, where N is the power in kilowatts, V the wind velocity in mps, and D the blade diameter in meters. The installation is designed to operate at wind velocities between 6 and 16 mps.

The structural strength of the blades is investigated, including the effect of aerodynamic forces, weight, centrifugal force, and gyroscopic couple. Shears and bending moments for the different loadings are calculated by numerical procedures. Details of the design calculations are given in tabular form.

D. Young, USA

3516. Marini, M., Calculation of aerodynamic inertia forces on sweptback wings (in Italian), *Aerotecnica* **32**, 6, 354–361, Dec. 1952.

Force and moment coefficients due to acceleration are calculated, by the method of doublets, for the heaving and pitching motion of a thin wing of constant chord in incompressible flow. Numerical results are given for sweepback $\phi = 45°$ and aspect ratio 6. They are compared with those for the unswept wing and also those obtained on strip theory. Author suggests that, if a coefficient has value C on strip theory and value kC on three-dimensional theory for unswept wings, then a rough approximation for swept wings may be $kC \cos \phi$.

R. E. Meyer, Australia

3517. Wijker, H., Experiments on the two-dimensional flow over a N.A.C.A. 0018 profile at high angles of attack, *Nat. Lucht-Lab. Amsterdam Rep.* A.1263, 14 pp., 1953.

Pressure distributions are measured over the surface of an NACA 0018 profile in two-dimensional flow at a Reynolds number of 2.7×10^6 for a range of attack angle α. The graph of lift coefficient c_L against α, corrected to aspect ratio 6, shows reasonable agreement with NACA measurements.

Transition and separation points of the boundary layer are found for a range of α extending beyond the stalling angle. The separation points of the turbulent boundary layer are in good agreement with theoretical predictions, considering the inaccuracies involved in both theory and experiment.

A. R. Mitchell, Scotland

3518. Letko, W., A low-speed experimental study of the directional characteristics of a sharp-nosed fuselage through a large angle-of-attack range at zero angle of sideslip, *NACA TN* 2911, 27 pp., Mar. 1953.

Results of an experimental investigation on the directional characteristics of a sharp-nosed fuselage model through a large angle-of-attack range are reported. The large increase in the yawing moment as the angle of attack increased is attributed to the asymmetric disposition of the pair of trailing vortexes emanating from the nose. A ring or other roughness used on the nose caused a large decrease in this yawing moment and a high angle of attack, and was even of opposite sense to that obtained with a plain fuselage. The effect of cutting off a certain length of the sharp nose was also investigated and was found to be of a similar nature.

G. V. R. Rao, USA

3519. McKoen, C. H., Resolution of velocity for the sweptback wing at incidence, *J. roy. aero. Soc.* **57**, 507, 117–179, Mar. 1953.

For an untapered swept wing with dihedral, set at an angle of attack, exact expressions are derived giving velocity components and local angle of attack for sections normal to leading edge. Numerical example shows comparison between exact and commonly used approximate values for a wing with 45° sweepback.

M. Zlotnick, USA

3520. Toms, C. F., Minimum comfortable cruising speed, *J. roy. aero. Soc.* **57**, 507, 180–182, Mar. 1953.

The minimum comfortable speed is defined here as the speed where the rate of climb due to changes in forward speed is 5% of the forward speed. The rate of climb is determined from static conditions; that is, the thrust and drag variations with speed. These relations are then used to determine that comfortable speed at which a turbojet and a turboprop aircraft should fly.

Author states that "inertia and longitudinal stability in the classical sense are unimportant factors" in determining the comfort boundary. It is reviewer's opinion that this assumption is not correct. Probably the most important factor affecting comfort in the aircraft longitudinal motion is the change in normal acceleration. The change in g due to forward speed variations is determined from the aircraft transient response. This response includes a rapid acceleration and pitch-up due to the short period mode, followed by the slow pitch angle and air-speed variation in the phugoid. The amplitude of the disturbance in normal acceleration is a function of static stability, equilibrium speed, wing loading, damping, and inertia. The increase in lift or g due to an increase in forward speed causes a decrease in angle of attack and so is related to an upward rate of climb. This rate of climb is determined by the short period characteristics, however, as noted before.

Reviewer also notes that the phugoid motion produces a slow oscillation in pitch angle which can be related to a rate of climb. It can be shown that the rate of climb per forward speed change in the phugoid is a function of pitch-angle change per nondimensional airspeed change. This function is independent of the thrust-drag relationships with speed.

Thus, it appears to this reviewer that, while the thrust and drag variations presented in this article are of interest for performance estimates, these variations cannot be used to determine the minimum comfortable speed.

F. W. Heilenday, USA

3521. Mathews, C. W., Talmage, D. B., and Whitten, J. B., Effects on longitudinal stability and control characteristics of a Boeing B-29 airplane of variations in stick-force and control-rate characteristics obtained through use of a booster in the elevator control system, *NACA Rep.* 1076, 17 pp., 1952.

Supersedes article reviewed in AMR **4**, Rev. 2619.

3522. Kochin, N. E., Steady vibrations of wing of circular plan form; and **Theory of wing of circular plan form,** *NACA TM* 1324, 93 pp., Jan. 1953.

Translations from *Prikl. Mat. Mekh.* **6**, 1942; **4**, 1940.

3523. Lessen, M., Considerations of the stability of plane, laminar, quasi-parallel flows, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 195–199, 1952. $6.

Squire's theorem on the stability of three-dimensional disturbances [*Proc. roy. Soc. Lond.* (*A*) **142**, 621–628, 1933] is extended to the case of compressible flows by an argument based on additional "plausible assumptions."

S. A. Schaaf, USA

3524. Bismut, M., Static measurements of aerodynamic derivatives for rolling motions (in French), *Rech. aéro.* no. 30, 9–13, Nov.-Dec. 1952.

Author presents some rolling-moment data of a model with rectangular and with 60° and 75° swept wings, measured by rotating model technique at tunnel Mach numbers 0.5, 1.425, and 1.71. The rolling-moment-derivative $\partial C_L/\partial p$ values agree with theory except for the 75° swept wing at $M = 1.71$. More data than those presented will be necessary to enable conclusive comparison with linearized theory. Yap Kie Jan, Holland

3525. Smith, A. M. O., On the motion of a tumbling body, *J. aero. Sci.* **20,** 2, 73–84, Feb. 1953.

A report on analytical and wind-tunnel investigations of the motion of releasable nose sections of two high-speed research airplanes. The results given indicate that, because of the great number of factors which influence tumbling motions and because of the apparent critical dependence of the motion on Reynolds number, it is difficult to predict full-scale results on the basis of wind-tunnel model tests.

Effects discussed which can cause autorotation are: (1) Anemometer-cup effect (possible even with axially symmetric bodies if e.g. is not on axis of symmetry); (2) falling strip of paper effect (related to hysteresis in C_L vs. α curve); (3) rotating dumbbell effect (related to rapid decrease of drag coefficient with Reynolds number near critical Reynolds number); (4) free-rotation effect (rotation may be induced on freely falling bodies which, if constrained to rotate about a single fixed axis, would not rotate).

R. M. Stewart, USA

3526. Brun, R. J., Serafini, J. S., and Gallagher, Helen M., Impingement of cloud droplets on aerodynamic bodies as affected by compressibility of air flow around the body, *NACA TN* 2903, 20 pp., Mar. 1953.

The trajectories of small spherical bodies (water droplets) in two-dimensional compressible flow around a circular cylinder were computed with a mechanical analog. The results of the calculations at approximately the flight critical Mach number were compared with those for incompressible flow. It was found that the effect of compressibility of the air on the droplet trajectories was negligible. It is conjectured that a similar result would be found for airfoils. J. R. Spreiter, USA

3527. Beavin, B. E., Sr., Zoning maps for airports, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 174, 9 pp., Feb. 1953.

Regulations and requirements for approaches to runways are discussed. Three-view drawings of approach dimensions are presented. Methods for making zoning maps are given.

H. R. Ivey, USA

Aeroelasticity (Flutter, Divergence, etc.)

(See Rev. 3522)

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 3490, 3491, 3556)

3528. Küchemann, D., and Weber, Johanna, Aerodynamics of propulsion, New York, London, Toronto, McGraw-Hill Book Co., Inc., 1953, ix + 340 pp. $9.

With the advent of jet propulsion, the interest in the aerodynamics of flow through ducts, intakes, and outlets has considerably increased. Because of the development trend toward the ramjet, this aspect of the propulsion problem may ultimately become all-important. Till now, the theoretical and experimental treatment of these problems could be found only in scattered publications. The book of Küchemann and Weber is the first to undertake the task of a systematic presentation of this field. The book contains several chapters which deal with the conventionally treated problems of propulsion: A carefully formulated but very concise introduction to the thermodynamics and the principles of propulsion; the cycle analysis of the ramjet and turbojet engines. However, the main emphasis lies in the chapters which deal with air intakes, fairings, propeller ducts, jet-engine installation, spreading and interaction of jets, and flow through cooler ducts. The authors have restricted themselves to the treatment of subsonic-flow problems. An appendix contains tables describing the flow field of singularities which may be used as elements for the construction of ideal flow patterns past ducts, intakes, etc.

The theoretical treatment of many of these problems is difficult, and the methods employed have not yet acquired the smoothness which would make them easy to teach. Küchemann and Weber, who have contributed many original papers in this field, deserve full credit for pioneering a systematic presentation of these theories. In the reviewer's opinion, however, the book is still written primarily for readers with previous experience in aerodynamics, as the application of these theories requires considerable flexibility and criticism. The book should be of great value for specialists and researchers in the field and for students of a more advanced level. N. Rott, USA

3529. Casci, C., A theoretical-empirical method for the design of turbines by means of two-dimensional theory (in Italian), *Monogr. Lab. Aero. Politecn. Torino* no. 285, 19 pp., 1952 = *R. C. Ist. Lombardo Sci. Lett.* **84,** 19 pp., 1951.

3530. Revuz, J., Blade profiles of axial compressors (in French), *Rech. aéro.* no. 31, 21–24, Jan.-Feb. 1953.

Fundamentals of a blade-profile calculation method is developed first. This procedure leads to a great simplification with respect to previous calculations, whose elements are recalled. The method of analogical determination is briefly explained and applied to a determined profile.

From author's summary by A. Balloffet, Argentina

3531. Fabri, J., and Bernard, J.-J., Flow of a perfect fluid through a centrifugal impeller having a great number of blades (in French), *Rech. aéro.* no. 30, 35–38, Nov.-Dec. 1952.

The fluid being incompressible, it is further assumed that a middle conical stream surface may be defined, from which all others do not deviate considerably within the impeller. The middle stream surface is then developed in a plane, where mass-flow continuity and irrotationality of absolute motion are postulated, leading to the definition of two auxiliary velocity functions which are harmonic in the case of constant blade height. Boundary conditions are especially simple when impeller is fitted with radial blades. A conformal transformation reduces the study to a Dirichlet problem on a unique straight segment. An approximate solution is given for high blade number. By means of trigonometric development of velocity functions, results may be generalized to the case of a specified radial variation of blade height.

Chief result is the occurrence of flow stagnation points on blade pressure face for small mass flows, a well-known theoretical fact which has been actually invalidated in most designs because of energy losses due to flow separation from suction face of curved impeller intake. Paper may be of mathematical interest, but.

owing to the essentially bidimensional treatment of perfect incompressible-flow problem, it actually adds nothing new to the somewhat obscure analysis of the flow through a centrifugal impeller. P. Schwaar, Switzerland

3532. **Jennings, B. H., and Rogers, W. L., Gas turbine analysis and practice,** New York, Toronto, London; McGraw-Hill Book Co., Inc., 1953, vii + 487 pp. $8.50.

Authors of this new book have designed a clear and particularly well-balanced text for the student of gas-turbine technology. The preparatory portion of the text begins with a closely knit chapter surveying appropriate thermodynamics material and containing a useful 30-page table of complete air properties at unit-degree temperature intervals. Following the usual analysis of cycles, authors encompass "practice" with chapters on over-all design features; axial-flow, centrifugal, and displacement compressors; aircraft and power-plant units; combustion; and mechanical problems of stress vibration, and materials. Analysis of some of the important research problems such as blade cooling is left essentially undeveloped in favor of "broad coverage."

The text is generously supplied with numerical examples and is well illustrated throughout. P. J. Schneider, USA

3533. **Rohlik, H. E., Allen, H. W., and Herzig, H. Z., Study of secondary-flow patterns in an annular cascade of turbine nozzle blades with vortex design,** *NACA TN* 2909, 29 pp., Feb. 1953.

Patterns of secondary flow were determined by use of hydrogen-sulfide traces, paint, flow fences, and total-pressure surveys. At one condition investigated, the radial transport of low-momentum fluid in the blade wake and on the suction surface near the trailing edge accounted for about 65% of the loss core; about 30% resulted from flow in the thickened boundary layer on the suction surface, and about 35% from flow in the blade wake.

The inner-wall loss core associated with a blade is largely the accumulation of low-momentum fluids originating elsewhere in the cascade. This accumulation is effected by the secondary-flow mechanism which acts to transport the low-momentum fluids across the channels on the walls and radially in the blade wakes and boundary layers. R. C. Binder, USA

3534. **Pascucci, L., Turbojet performance as a function of operating conditions** (in Italian), *Aerotecnica* **33,** 1, 94–99, Feb. 1953.

Changes of thrust, air specific impulse, and specific fuel consumption resulting from changes of flight altitude, Mach number, and engine rpm are calculated for turbojets of fixed exhaust area. Analytical model involves constant-pressure combustion, assumption that small-stage efficiencies of compressor and turbine be independent of rpm, and other simplifying assumptions which are likely to limit validity of results to a relatively narrow range of operating conditions. Qualitative trends are, however, clearly indicated. J. V. Foa, USA

3535. **Numachi, F., Cavitation tests on hydrofoils in cascade,** ASME Ann. Meet., New York, Dec. 1952. Paper no. 52—A-87, 12 pp., 20 figs.

The object of this study was to determine the effect of cavitation on the lift and drag coefficients of certain hydrofoils arranged in an infinite cascade. Experiments were conducted in a closed water tunnel on five hydrofoils with chord and breadth each equal to 100 mm at a cascade angle of 25.73°. The ratio of the hydrofoil spacing to chord was 1.237. The hydrofoils tested were Clark Y 6%, Clark Y.H. 6%, and ogival 6%.

The apparatus was unique in that the upper and lower walls of the tunnel behind the cascade were made movable so as to permit their direction to be adjusted to coincide with that of the exit velocity of an ideal flow passing through the hydrofoils arranged in an infinite cascade. The effects of wall interference in the working section on the exit velocity are thus compensated for by this innovation, permitting a finite cascade section to be investigated. In conventional wind tunnels, experiments of this kind are usually carried out in such a manner that the exiting flow emerges as a free jet; by approximating these conditions in the water tunnel, the author proves that free-jet efflux brings about discontinuities in the characteristic curves for a finite cascade.

Cavitation tests on each type of hydrofoil were conducted at various angles of attack and Reynolds numbers. Lift and drag coefficients are obtained for the various angles of incidence and for varying degrees of cavitation as expressed by a cavitation parameter. Conditions under which danger of erosion due to cavitation and strong vibrations occurs are also stated. The behavior of each type of hydrofoil operating singly and in a cascade is presented, as well as several photographs of the apparatus and plots of the experimental results. C. E. Carver, Jr., USA

3536. **Bovet, G. A., Modern trends in hydraulic turbine design in Europe,** *Trans. ASME* **75,** 6, 975–988, Aug. 1953.

This paper deals with modern trends in the design of hydraulic turbines in Europe, especially in so far as they differ from standard American practice. The paper describes and discusses the general arrangement of large hydro-units, the use of high-grade alloys, the efficiency tests of large turbines, various improvement in speed regulation, and departures from accepted practice in the field of gates and valves. From author's summary

3537. **Pantell, K., Efficiency step-up formulas from model to prototype for hydraulic turbines and pumps** (in German), *ZVDI* **95,** 4, 97–100, Feb. 1953.

Author discusses these formulas for turbines by European authors, including his own and Prof. Moody's of the United States, but fails to refer to broader discussion of same subject by Davis, Pardoe, Sharp, Winter, and others in the *Amer. Soc. civ. Engrs. Trans.* **106,** 353–397. He shows that as the reduced percentage loss L of the prototype appears as $1 - L$ for turbines [Eq. 20] and $1/(1 + L)$ for pumps [Eq. 30] of similar size ratio, the efficiency step-up ratio is greater for the latter.

He warns that, while these evaluations are enlightening, a definite guarantee ($\pm 2\%$) based on step-up calculations could hardly be considered safe. A. Hollander, USA

3538. **Fabri, J., and Siestrunck, S., Study of the supersonic propeller,** *NACA TM* 1355, 23 pp., Mar. 1953.

See AMR 6, Rev. 614.

3539. **Corson, B. W., Jr., and Maynard, J. D., The Langley 2000-horsepower propeller dynamometer and tests at high speed of an NACA 10-(3)(08)-03 two-blade propeller,** *NACA TN* 2859, 75 pp., Dec. 1952.

Tests have been made for a range of blade angles from 20° to 55° at airspeeds up to 500 mph. The maximum efficiency of 0.93, which was attained over a range of advance ratio from 1.3 to 2.0 for a constant rotational speed of 1,350 rpm, reflects the importance of designing for a minimum-induced-energy-loss loading and the use of efficient airfoil sections from the spinner surface to the propeller tip. When the helical-tip Mach number is increased from 0.90 to 1.15, the corresponding loss in propeller efficiency is about 21% at a blade angle of 45°.

From authors' summary

Flow and Flight Test Techniques

3540. Petersohn, E. G. M., Some experimental investigations on the influence of wall boundary layers upon wind-tunnel measurements at high subsonic speeds, *Flygtekn. Försöksanst. Medd.* no. 44, 16 pp., 1952.

The thickness of the boundary layer on the walls of a wind tunnel was varied in order to study its influence on pressure and drag measurements on two-dimensional models at high subsonic speeds. It is to be expected that when the boundary layer is very thick, the flow conditions will tend toward those in an open jet tunnel. The tests indicated that a thicker boundary layer reduced the disturbing influence of the tunnel walls on the model and increased the choking speed for a given model.

G. N. Patterson, Canada

3541. Scherer, M., Wind-tunnel measurements on aerodynamic derivatives of models by means of a method of sustained oscillations (in French), *Rech. aéro.* no. 30, 15–18, Nov.-Dec. 1952.

Paper gives brief description of model support system with six degrees of freedom. Movement in each degree of freedom can be controlled or excited independently of the others. Method of using apparatus to measure stability derivatives is outlined, with examples. System can also be used for studying effect of controls.

W. A. Mair, England

3542. Evans, A. J., The zero-lift drag of a slender body of revolution (NACA RM-10 research model) as determined from tests in several wind tunnels and in flight at supersonic speeds, *NACA TN* 2944, 40 pp., Apr. 1953.

Zero-lift drag data are presented for a Reynolds number range from about 1×10^6 to 40×10^6 from several wind tunnels, and from about 12×10^6 to 140×10^6 from free-flight tests. The Mach numbers covered include 1.5 to 2.4 for the wind-tunnel data and 0.85 to 2.5 for the flight results. The wind-tunnel models were tested with and without 60° sweptback stabilizing fins, and the flight models were tested with stabilizing fins. Comparison of the data obtained in the several wind tunnels for the body alone (without fins) shows goo ! agreement between the different facilities. There are unexplained differences, however, between the wind-tunnel results with fins attached and flight results, as well as differences between full-scale and half-scale flight models, which cannot be explained as an effect of Reynolds number. The results presented are compiled in the present paper to facilitate the correlation of results obtained in other test facilities.

From author's summary by G. B. Schubauer, USA

3543. Weibel, E. E., A new quantitative optical method applied to fluid flow problems, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 693–698, 1952.

Author describes method of modifying a schlieren optical system to make quantitative measurements of gas density in a two-dimensional field. Modification consists of replacing customary knife edge with a screen grid located slightly beyond usual focal-point location of knife edge. Resultant image is enlarged shadowgraph of screen grid. Variations in gas density at test point are revealed by distortion of grid shadowgraph image. Grid shadow image distortions are analyzed for corresponding gas density by applying theory based on analogous theory for electron shadow optics.

Sensitivity of method is limited by diffraction effects and is below that of interferometer. Method measures density gradients, necessitating a numerical integration to obtain density. However, equipment is adequately sensitive for many studies and is relatively inexpensive.

T. P. Clark, USA

3544. Bendersky, D., A thermocouple for measuring transient temperatures, *Mech. Engng., N. Y.* **75,** 2, 117–121, Feb. 1953.

Article describes the construction of a steel vs. nickel thermocouple having a junction thickness of 1 micron and an estimated time constant of $^1/_4$ microsec, and used for measuring the very rapid surface temperature changes in gun barrels at or near the bore surface. The probe consists of a steel tube 0.09-in. diam and about $^1/_2$ in. long, with a nickel lead wire through the center and insulated from the steel tube by an oxide coating. A junction is formed by plating a thin layer of nickel on the end of the probe, which also joints the steel tube to the nickel lead wire. The probe is held in a steel body equipped with external threads for mounting.

J. E. Brock, USA

3545. Brantley, J. Q., Jr., A study of the aircraft collision problem with particular emphasis on the possible application of continuous wave radar techniques, *Cornell aero. Lab., Inc. Rep.* no. JA-774-P-1, 89 pp., Sept. 1952.

Report describes study of accidental aircraft collisions. Mathematical relationships associated with collisions are developed. Author concludes that continuous wave radar is preferable to pulsed radar. Discussion is given of radar antenna requirements and computer requirements.

H. R. Ivey, USA

3546. Johnson, D. P., and Newhall, D. H., The piston gage as a precise pressure-measuring instrument, *Trans. ASME* 75, 3, 301–310, Apr. 1953.

The errors which must be considered for accurate measurements of pressure with piston gages are discussed. A new design of piston gage is described which permits the operator to control the clearance between piston and cylinder at any operating pressure. Instrumental errors are thus substantially reduced, particularly those resulting from elastic distortion. A check list of errors inherent to piston gages is presented. These errors are to be considered when instruments are used to accuracies better than $^1/_4$ of 1%.

The need for a check on the long-time variations of the piston gage is supplied by the fixed points, changes of state of some very pure materials which take place at definite pressures. Such are the melting pressure of solid mercury at 0C, the melting pressure of water at 30C, the transition between crystalline states of bismuth. As an indication of its possibilities, the experimental model of the controlled-clearance piston gage was used to measure the melting point of mercury at 0C. Results were in satisfactory agreement with Bridgman's value.

From authors' summary by G. S. Cherniak, USA

3547. Hengeveld, J. F., Ditching tests on a $^1/_8$-size model of the Fokker S-13 crew trainer, *Nat. LuchtLab. Amsterdam Rep.* A.1238, 5 pp., 12 figs., 1951.

This report gives experimental results of ditching tests conducted at the Nationaal Luchtvaartlaboratorium Open Air Ditching Station on a dynamically similar $^1/_8$-scale model of the Fokker S-13 Crew Trainer. Systematic tests were made concerning the influence on the landing run and deceleration forces of such variables as speed, attitude, center-of-gravity location, etc. From the model tests, conclusions were drawn as to best ditching procedure for the full-scale aircraft. In general, it was found that a combination of a high angle of attack and low approach speed gave landing runs of the order of six aircraft lengths, and decelerations less than 2g.

F. L. Wattendorf, USA

Thermodynamics

(See also Revs. 3571, 3581)

3548. **Ribaud, G., Thermodynamic constants of gases at elevated temperatures** (in French), *Publ. sci. tech. Min. Air, Paris* no. 266, 169 pp., 1952.

An excellent survey of modern theories of specific heat and the methods of calculating thermodynamic properties of gases at high temperatures. Chaps. 1 and 2 give a review of equations interrelating in differential form various thermodynamic properties, as well as a discussion of the equations of state for the perfect and the real gas. In chap. 3, experimental methods for measuring specific heats are presented and discussed. Chap. 4 discusses the various forms of energy associated with a molecule, and the following four chapters give the details of method of calculation. The concluding chapter gives illustrative examples of the calculations discussed; properties of some 50 (inorganic and organic) gases are tabulated. M. J. Goglia, USA

3549. **Codegone, C., Specific heat, enthalpy, and the Prandtl coefficients of gases and vapors** (in Italian), *Monogr. Lab. Aero. Politec. Torino* no. 299, 10 pp., 1952 = *Atti Accad. Sci. Torino* 86, 1951–1952.

Author claims extension of the law of corresponding states to enthalpy, internal energy, isobaric and isochoric specific heats and Prandtl coefficient of gases, having carried out this extension to viscosity and thermal conductivity in two previous notes [AMR 6, Revs. 2914, 2915]. Author claims to have obtained acceptable correspondence using fictitious enthalpy and temperature obtained by adding suitable constants.

Reviewer believes that these claims (which contradict accepted statistical mechanical theories) are not confirmed by the data presented in this paper. S. Gratch, USA

3550. **Murdock, J. W., and Foltz, C. J., Experimental evaluation of expansion factors for steam,** *Trans. ASME* 75, 5, 953–959, July 1953.

Paper presents experimental data for flow of steam at superheats from 29 to 255 F and pressures of 44 to 102 psi through orifices with ratios from 0.30 to 0.82. From the results, it is concluded that the ASME empirical expansion factor Y for orifice-measuring of compressible fluids, which is based mainly on tests with natural gas and air, is valid for superheated steam, and tolerances for this vapor should be the same as those for air and gases.

From authors' summary by A. F.W. Langford, Australia

3551. **Popoff, K., On heat transfer by conduction from one system to another** (in French), *C. R. Acad. Sci. Paris* 236, 8, 785–786, Feb. 1953.

Author applies thermodynamic principle of irreversible processes to a simple problem, i.e., to determine the rate of heat flow between two bodies in contact. Result is an interesting example of this method. L. S. Dzung, Switzerland

3552. **Matz, W., Collection of examples on the thermodynamics of heat and mass exchange [Aufgabensammlung zur Thermodynamic des Wärme- und Stoffaustausches in der Verfahrenstechnik],** Darmstadt, Verlag von Dr. Dietrich Steinkopff, 1953, xii + 138 pp., 29 figs.

Text is a companion volume to author's book which appeared previously under the same title [AMR 4, Rev. 4607]. In this volume, one-hundred problems and their solutions are given. A unique approach is the introduction preceding each problem and explaining the applications to actual cases. Thus the reader is enabled to bridge academic study with industrial experience.

The problems are original and constitute a stimulating challenge to the thermodynamicist. The solutions make liberal use of mathematics, and the treatment is mature. Figures and graphical solutions are given whenever worth while. Topics included are: Fundamental laws, equilibrium, similitude, multiple phases, distillation, adsorption, absorption.

Text is a contribution to the thermodynamics of heat and mass exchange. A. B. Cambel, USA

3553. **Tischler, A. O., and Bellman, D. R., Combustion instability in an acid heptane rocket with a pressurized-gas propellant pumping system,** *NACA TN* 2936, 50 pp., May 1953.

Results of experimental measurements of low-frequency combustion instability of a 300-lb thrust acid-heptane rocket engine were compared with the trends predicted by an analysis of combustion instability in a rocket engine with a pressurized-gas propellant pumping system. The simplified analysis, which assumes a monopropellant model, was based on the concept that a combustion time delay occurred from the moment of propellant injection to the moment of propellant combustion. This combustion time delay was experimentally measured; the experimental values were approximately half the magnitude predicted by the analysis. The pressure-fluctuation frequency for a rocket engine with a characteristic length of 100 in., operated at a combustion-chamber pressure of 280 psia, was 38 cps; the analysis indicated a frequency of 37 cps. Increasing combustion-chamber characteristic length decreased the pressure-fluctuation frequency, in conformity with the analysis. Increasing the chamber operating pressure or increasing the injector pressure drop increased the frequency. These latter two effects are contrary to the analysis; the discrepancies are attributed to the conflict between the assumptions made to simplify the analysis and the experimental conditions. Oxidant-fuel ratio had no apparent effect on the experimentally measured pressure-fluctuation frequency for acid-heptane ratios from 3.0 to 7.0. The frequencies decreased with increased amplitude of the combustion-chamber pressure variations. The analysis indicated that, if the combustion time delay was sufficiently short, low-frequency combustion instability would be eliminated.

From authors' summary by J. H. Childs, USA

3554. **Berman, K., and Cheney, S. H., Jr., Combustion studies in rocket motors,** *J. Amer. Rocket Soc.* 23, 2, 89–96, Mar.-Apr. 1953.

Combustion instability was investigated with 3-in. diam, 1200-lb-thrust rocket motors, some of which had slit windows in the chamber walls. Propellants were ethyl alcohol and liquid oxygen. Principal instrumentation consisted of a GM-type dynagage pressure pickup connected to a recording oscillograph, and a continuous strip film camera.

Two general types of chamber pressure oscillations were encountered: a sinusoidal-type and a more severe shock-type oscillation which was characterized by a somewhat higher frequency, a greater peak-to-peak amplitude (200 to 500 psi), and much higher chamber heat-transfer rates (1.5 to 2.5 times normal). The results confirm that high-frequency combustion instability in small rocket motors is the result of longitudinal pressure pulses, with the frequency being a function of chamber length. The severity of the instability is increased by low injector pressure drop, long chamber lengths, and rapid nozzle convergence. For large amplitude oscillations, the radiation pattern shows the existence of shock waves in the chamber. With the reflection of each shock wave at the injector, a nonluminous region forms and moves downstream at the existing gas velocity. These nonluminous

gases may result from differences in the responses of the fuel and oxidizer lines to pressure changes. J. H. Childs, USA

3555. Penner, S. S., On maximum evaporation rates of liquid droplets in rocket motors, *J. Amer. Rocket Soc.* **23,** 2, 85–88, 98, Mar.-Apr. 1953.

Using a highly simplified model, author calculates evaporation times for 50 and 100-micron radius aniline, octane, and hydrazine drops. M. Tribus, USA

3556. Heil, J. W., Efficiency increase of Diesel engines (in Dutch), *Schip en Werf* **20,** 7, 135–140, Mar. 1953.

Short theoretical introduction followed by a discussion of papers referring to experimental data about efficiency of diesel engines [*ZVDI*, 1113–1123, 1951; *Motorship* p. 312, 1951; *Brown Boveri Mitt.* p. 25, 1952; title source pp. 41, 73, 1953]. D. ter Haar, Scotland

3557. Matsuda, S., On the superlattice formation in ternary alloys, *J. phys. Soc. Japan* **8,** 1, 20–25, Jan.-Feb. 1953.

Author discusses the superlattice formations in a ternary alloy with a body-centered cubic lattice, by taking into account the interaction energies with nearest and next nearest neighboring atoms. The thermodynamic equilibrium conditions for the A_2BC, $A(BC)$, and $(AB)_2C$ superlattice are obtained. The Cu-Al-Mn system is discussed. H. D. Vasileff, USA

3558. Houdremont, E., and Krisement, O., Considerations on the effect of cooling of the transformation components in view of martensite production (in German), *Arch. Eisenhüttenw.* **24,** 1/2, 53–68, Jan./Feb. 1953.

A mathematical investigation of mechanical stress and work, as well as a thermodynamic consideration of structure transformation: Hysteresis of the A_3-transformation of pure iron; austenite-martensite transformation of iron-carbon alloys; calculation of martensite temperature of formation; heat evolution of the austenite-martensite transformation; critical size of the martensitic nuclei; relation between the retained austenite and crystal constant measurement; the ν-α transformation of iron-nickel alloys, and γ-ϵ transformation of iron-manganese alloys; transformation of the iron-carbon alloys in the pearlite and intermediary stage.

From authors' summary by H. D. Vasileff, USA

3559. Murakami, T., Atomic distribution in binary solid solutions. I. General theory, *J. phys. Soc. Japan* **7,** 6, 549–554, Nov.-Dec. 1952.

The atomic distribution functions of a binary solid solution are investigated and brought into a form intimately related to the distribution functions of the statistical theory of imperfect gases [Montroll and Mayer, *J. chem. Phys.* **9,** 626, 1941]. The only difference is that volume integration is replaced by a lattice summation. Therefore, the methods developed in the theory of imperfect gases, especially Ursell's expansion with the concept of the cluster integral being replaced by the cluster sum, are applicable and used to calculate the radial distribution function for two equal atoms. Only chains of equal atoms without internal connections are taken into consideration. For systems with only nearest neighbor interactions, the temperatures at which singularities of the distribution function occur are determined and identified with the transition temperature. The results for several lattices are not in general agreement with those of Bethe.

J. Meixner, Germany

3560. Murakami, T., Atomic distribution in binary solid solutions. II. Modified theory for the case of nearly equal concentrations, *J. phys. Soc. Japan* **8, 1,** 31–35, Jan.-Feb. 1953.

This paper extends the theory (see preceding review) by taking into account also chains without internal connections, but with different kinds of atoms. The results for the transition points in case of nearest neighbor interaction agree with Bethe's, except for the critical temperature of order-disorder transitions in triangular and face-centered cubic lattices.

J. Meixner, Germany

3561. Murakami, T., Atomic distribution in binary solid solutions. III. Diffuse scattering of x-rays by binary alloys, *J. phys. Soc. Japan* **8,** 1, 36–40, Jan.-Feb. 1953.

Starting from the radial distribution functions for binary alloys, as developed in the two preceding reviews, the diffuse scattering of x rays at temperatures above the transition point or the phase separation point due to partial ordering of the two kinds of atoms is calculated. The theory predicts the disklike shape of the diffuse maxima observed for Cu_3Au, while no such anomalous shape seems to appear for systems which separate into two phases at the critical temperature. J. Meixner, Germany

3562. Moote, Irene, The effect of moisture on the thermal properties of wheat, *Canad. J. Technol.* **31,** 2/3, 57–69, Feb./Mar. 1953.

Thermal properties of wheat containing from 1.4 to 15.9% moisture were determined by measuring the radial temperature gradient in a cylindrical sample heated along its axis. Difficulties were encountered because of the migration of moisture from points of high to points of low temperature. The following conclusions are drawn: Thermal conductivity is 0.00030 cal per cm sec ° C for dry wheat and increases approximately 0.000007 cal per cm sec ° C for every 1% dry weight increase in moisture content; thermal diffusivity is 0.0012 sq cm per sec for dry wheat and decreases slightly with increase in moisture content; specific heat is 0.31 cal per gm ° C for wheat and increases with moisture content. All three properties vary slightly, depending on the kind of wheat.

H. J. Stoever, USA

3563. Houberechts, A., and Patigny, J., The cooling of deep mining shafts (in French), *Chaleur Industrie* **34,** 331, 31–42, Feb. 1953.

Authors discuss in general various aspects of ventilation and cooling of deep coal-mine galleries under such headings as climatic and physiologic problems, influence of mechanical mining equipment, effect of simple ventilation, artifical refrigeration, and description of two refrigeration installations in deep mines. In more specific terms they give a relation for the effective temperature, $t_e = 0.9t_{WB} - 0.1t_{DB} < 93$ F, approximately, as the criterion of satisfactory conditions under continuous mining labor. Calculations are presented, in the form of a composite plot, relating production of coal to cooling load and air circulation requirements for various entering air temperatures. Experimental data obtained on actual-size model galleries are also presented, giving in tabular form the pressure drop and power consumption for an air-flow rate of 50 m^3 per sec and various types of construction and cross sections of galleries. Data are presented in tabular form for five actual mines giving the physical characteristics of each and the magnitude of the various heat sources in each mine, in actual values and as percentage of the total load. The problem of temperature cycles, thermal lag, and temperature gradients are discussed and figures reported. For one of the refrigeration systems described, a C.O.P. of 7.15 is claimed.

Y. S. Touloukian, USA

Heat and Mass Transfer

(See also Revs. 3295, 3502, 3549, 3552)

3564. **Minasyan, R. S., Unsteady heat flow in a prismatic body with transverse section in the form of a right angle in the presence of unsteady heat sources** (in Russian), *Prikl. Mat. Mekh.* **16**, 5, 533–538, Sept./Oct. 1952.

The planar nonstationary heat distribution is considered in a prismatic body whose transverse cross section has the form of a carpenter's square. The initial heat distribution within the region is given. The temperature along the boundary of the region is a given function of time. It is assumed that there exist unsteady heat sources within the region, and that the temperature $U(x, y, t)$ is symmetrically distributed, i.e., $U(x, y, t) = U(y, x, t)$. The method of Laplace transforms is used to reduce the problem to the solution of an infinite system of linear algebraic equations, which is shown to possess a solution.

Courtesy of Mathematical Reviews H. P. Thielman

3565. **Jaeger, J. C., Pulsed surface heating of a semi-infinite solid,** *Quart. appl. Math.* **11**, 1, 132–137, Apr. 1953.

Using the Laplace transform, formulas are developed for temperature distribution in a semi-infinite slab where the flux of heat at the inner surface is represented by periodic rectangular pulses. When the prescribed heat flux is supplied over the whole surface, the temperature at the inner surface is given for all values of time in three terms; the first corresponding to steady heating due to an average flux, the second being the steady periodic part, and the third, an integral expression due to the branch point in the inversion integral which is negligible for large values of time. An integral expression is given for the steady periodic part in terms of the ratio of heating time to period. A graph shows the effect of this ratio on temperature and another shows temperatures at beginning and end of a heating interval.

The limiting case of instantaneous pulse heating is considered. The method of obtaining expressions for temperatures at any depth is indicated by giving the solution for this case for large values of time.

The author sees no justification of the Comenetz conjecture [AMR **1**, Rev. 753].

The case when the rectangular heat pulse is applied over a circle is considered, with temperature at the center of the circle being given after steady conditions have been attained. Maximum values of the steady periodic term are plotted. Under similar conditions the cases of pulsed point and line sources are considered. G. A. Hawkins and E. A. Trabant, USA

3566. **Parkes, E. W., The alleviation of thermal stresses,** *Aircr. Engng.* **25**, 288, 51–53, Feb. 1953.

Influence of surface insulation on transient temperature distribution in a thick slab is considered. Numerical results are presented for a family of cases in which the surface temperature increases uniformly to a fixed amount and thereafter remains constant. Author uses results to judge possibility of alleviating thermal stresses in aircraft, and concludes that even a paint layer may be very beneficial in reducing transient thermal stresses.

S. Levy, USA

3567. **Olsen, J. L., and Rosenberg, H. M., The thermal conductivity of metals at low temperatures,** *Advances in Phys.* **2**, 5, 28–66, Jan. 1953.

A somewhat lengthy review is given of the existing experimental work on low-temperature thermal conductivity of metals. Where possible, comparison is made with existing theories without analyzing these in detail. Transfer of heat in a metal is attributed to the two types of conductivity, viz., electronic, Ke, and lattice, Kg, conduction. Topics concerning these appear in the following order: (1) Variation with temperature of Ke in normal metals; (2) effect on Ke of small impurity content, magnetic field, and crystal anisotropy; (3) variation with large impurity content of Kg and Ke in metals and in alloys; (4) superconductivity and the regime below 1° K.

Of special interest to cryogenic engineers will be the section on alloys for cryogenic apparatus and the list given of recent papers on thermal conductivity of alloys.

In closing, the authors give an account of the outstanding problems they consider important for immediate investigation.

F. D. Bennett, USA

3568. **Tang, Y. S., Duncan, J. M., and Schweyer, H. E., Heat and momentum transfer between a spherical particle and air streams,** *NACA TN* 2867, 48 pp., Mar. 1953.

Authors describe experimental work undertaken to measure heat-transfer coefficients for spherical particles. Carbon-steel particles ranging in size from $^1/_8$ in. to $^5/_8$ in. were heated by an induction system in a moving air stream. Data at air velocities of 1 to 13 fps and Reynolds numbers of 50 to 1000 were obtained. An empirical equation for Reynolds number vs. Stanton number was obtained and was found to compare favorably with values computed from theory.

Publication contains much valuable information to those dealing with heat, mass, and momentum transfer.

A. B. Cambel, USA

3569. **Stalder, J. R., Goodwin, G., and Creager, M. O., Heat transfer to bodies in a high-speed rarefied-gas stream,** *NACA Rep.* 1093, 9 pp., 1952.

Supersedes article reviewed in AMR **5**, Rev. 819.

3570. **Ramdas, L. A., Convective phenomena near a heated surface,** *Proc. Indian Acad. Sci. (A)* **37**, 2, 304–316, Feb. 1953.

The behavior of the thermal boundary layer around a horizontal heated plate is described qualitatively; a comparison is made of the cellular type of natural convective mixing that occurs above the plate with the random fluctuations of atmospheric temperature that occur during the day above hot ground. A brief, qualitative review is given of the author's work since 1932 on atmospheric micrometeorology, with special reference to heat exchange.

Measurements of the excess pressure developed on the face of a plate facing a hot surface, owing to thermal diffusion effects in the gas surrounding the plate, are described. The results show that, as the gas pressure was varied, the unbalanced force developed on the plate reached a maximum at a pressure around 0.1 mm mercury absolute. R. L. Pigford, USA

3571. **Nicol, J., Smith, T. S., Heer, C. V., and Daunt, J. G., A new type of heat interchanger for large liquefiers,** *Rev. sci. Instrum.* **24**, 1, 16–19, Jan. 1953.

Details are given of the design and performance of a heat interchanger suitable for transferring heat from a gas of high heat content per unit volume to one of low heat content per unit volume. The interchanger is suitable for use in large liquefiers, and a report is given of its performance in a helium liquefier giving 6.5 liters of liquid helium per hr. The construction is simple and involves no techniques not already available in an average laboratory workshop. A close correlation is reported between the computed and observed efficiencies and pressure drops in these interchangers. From authors' summary

3572. Sunde, G., and Sundholm, O. A., Tests on fabricated spherically dished floating cover for heat exchanger, ASME Ann. Meet., New York, Dec. 1952. Paper no. 52—A-147, 16 pp., 8 figs.

Two identical spherically dished floating tube sheet covers, 26-in. diam, 30-in. radius of dish, $^9/_{16}$-in. nominal thickness, designed for 300 psi, were bolted together so that, with water pressure applied inside the assembly, one head had pressure on the concave side and the other had pressure on its convex side.

A maximum pressure of 1140 psi was applied, deflection readings of the surfaces being taken at 50 psi increments up to 800 psi. The head with pressure on convex side showed some permanent distortion after the pressure had exceeded 800 psi. Both heads withstood a pressure of at least 3.5 times the design pressure.

B. E. Short, USA

3573. Allen, D. N. de G., The calculation of the efficiency of heat regenerators, *Quart. J. Mech. appl. Math.* **5,** part 4, 455–461, Dec. 1952.

This paper discusses the details of the numerical solution of an equation of the form $\partial^2 T/\partial X \partial Z + \partial T/\partial X + \partial T/\partial Z = 0$, as used for the prediction of performance of heat exchangers of the regenerative type. T is the matrix temperature, X is normalized flow position, and Z normalized time.

The numerical solutions so obtained have been reported earlier by Saunders and Smoleniec [AMR **3,** Rev. 2513; also General Discussion on Heat Transfer, Proceedings, IME, ASME, 1951]. This paper deals only with the method used and questions of convergence. The method employed is the well-known relaxation technique on successively finer nets. Comparison of the integrated result for the "thermal ratio" of the exchanger, from three successive nets, allows an estimate of the "exact value" to three significant figures. A. L. London, USA

3574. Kollmar, A., Principles of heating by radiation (in German), *ZVDI* **95,** 2, 33–38, Jan. 1953.

A detailed discussion of the physiological heating requirements for man and of various heating systems is given. The effects of various types of heating systems on the mean radiant temperature are outlined. The radiation configuration factors for various wall, floor, ceiling, and window surfaces are discussed. The calculation of the required heating areas is outlined.

W. L. Sibbitt, USA

3575. Frenkel, M. S., Direct separation evaporators, *Engng. and Boiler House Rev.* **67,** 9, 252–259, Sept. 1952.

3576. Frenkel, M. S., Cyclic arrangement of direct separation evaporators, *Engng. and Boiler House Rev.* **67, 10,** 296–298, Oct. 1952.

3577. ter Linden, A. J., Cyclone dust collectors for boilers, *Trans. ASME* **75.** 3, 433–440, April 1953.

After dealing with the settling of dust particles leaving stacks of different heights, author describes several types of cyclones tested in his own laboratory. For cyclones of the straight-through type, efficiencies are plotted against shunt flow. For conventional type (with tangential inlet and conical underportion), the influence of exhaust-pipe diameter and length, and furthermore, the relation of efficiency to pressure drop are shown in curves. Especially interesting are the graphical data concerning total and static pressures and tangential, radial, and vertical velocities at different points in the cyclone of author's modified design. It is shown that for the predominant tangential velocity component, the formula $v_t r^{0.5} = \text{const}$ holds approximately, so that the flow in the sections perpendicular to axis has a character of a potential vortex. Influence of cyclone size and general arrangement of multicyclones are also discussed.

O. Maštovský, Czechoslovakia

Acoustics

3578. Altenburg, K., and Kästner, S., Demodulation of ultrasonic waves in liquids (in German), *Ann. Phys.* (6) **11,** 2/3, 161–165, 1952.

An ultrasonic wave modulated by an audiofrequency signal is demodulated directly by an audio microphone in a fluid because the radiation pressure fluctuates at the modulation frequency and its first harmonic. Authors find experimentally that (1) the received audio amplitude depends linearly on both the degree of modulation and the carrier energy density; (2) the amplitude of the first harmonic depends quadratically on the degree of modulation. Results confirm simple theory. Authors have little hope for practical use of effect, but it has been used recently to determine ultrasonic absorption in liquids [McNamara and Beyer, *J. acoust. Soc. Amer.* **24,** 453, 1952]. R. W. Morse, USA

3579. Kramer, M., The aerodynamic profile as acoustic noise generator, *J. aero. Sci.* **20,** 4, 280–282, 296, Apr. 1953.

This article reviews briefly the sources of propeller noise which are of two types, namely, (1) rotational noise, which consists of harmonics of the blade passage frequency and is associated with the steady air loads on the blades, and (2) profile or vortex noise, which has a random frequency spectrum and is associated with the unsteady air forces. The author treats the profile noise and presents a new concept for its sources. He believes that it originates from the turbulence in the air through which the blade passes, rather than from the shedding of the vortexes in the boundary layer. Certain laboratory experiments, including boundary-layer suction, are discussed and some effects of Mach number on profile noise are presented. The author believes that the profile noise is the predominant source of propeller noise in flight and he cites some fly-by tests of an airplane. This is contrary to the generally accepted belief that the rotational noise of the propeller is the predominant source of noise for conventional propellers.

Although the article is thought-provoking, reviewer believes the evidence presented is not conclusive. The reviewer takes especial exception to the statement that the profile noise predominates. In some noise tests which the reviewer made with an airplane flying past the microphone, the sound analyzer could not distinguish the rotational noise because of the Doppler effect on the frequency. When the pilot was asked to circle the microphone position so as to keep a constant distance, the first five harmonics of the rotational noise could be readily determined by the analyzer up to distances exceeding 5000 ft. The rotational noise is also the primary source of cabin noise in conventional airplanes, as may be observed from the spectrums published in an article by Rudmose and Beranek [title source, **14,** 2, 79–96, Feb. 1947]. A. A. Regier, USA

3580. Veneklasen, P. S., Noise characteristics of pulse-jet engines, *J. acoust. Soc. Amer.* **25,** 3, 378–380, May 1953.

Data are presented of the noise characteristics of two sizes of pulsejets as tested on a test stand. Some interesting remarks are made of the noise characteristics of pulsejets mounted on helicopter blades, including Doppler effects on the frequencies. Comparisons are made of the noise of the small pulsejets with the

noise of conventional turbojets and multi-engine propeller aircraft. This comparison shows the pulsejet to be a very intense noise source, even though its thrust may be presumed to be only a small fraction of that of the other power plants.

A. A. Regier, USA

3581. **Post, E. J., On the characteristic temperatures of single crystals and heat dispersion of the "Debye heat waves,"** *Canad. J. Phys.* **31**, 1, 112–119, Jan. 1953.

In a crystalline medium with density ρ and elastic constants c^{klrs}, the displacement amplitude p_k for a wave traveling with phase velocity c in the direction n_l obeys the equation $c^{lkrs}n_l n_s p_r = \rho c^2 p^k$. Author introduces approximation of averaging over all directions n_l with equal probability, so that $n_l n_s$ is replaced by $\frac{1}{3}\delta_{ls}$. The distinction between transverse and longitudinal waves in an isotropic medium is thereby lost.

In considering numerical data, author observes that best experimental values of the scalar invariant $c^{ls}{}_{ls}$ are systematically higher for single crystals than for polycrystals.

F. R. N. Nabarro, England

3582. **Stokes, G. M., and Davis, D. D., Jr., The attenuation characteristics of four specially designed mufflers tested on a practical engine setup,** *NACA TN* 2943, 30 pp., May 1953.

Noise reduction is a significant problem in present-day aircraft design. More effective mufflers could reduce the high noise level associated with the exhaust system. Four practical mufflers were designed and tested in laboratory with pure sine wave, low-amplitude input signals, and zero flow velocity; all attenuations agreed with theoretical predictions. But in field, on a test helicopter, all four showed markedly less attenuation; the highest attenuation of about 40 db in the noisiest range from 70 to 350 cps was reduced to about 10 db. Paper clearly indicates need and direction of further experiments to explain this loss of attenuation and thereby improve muffler design. Factors to be considered include flow velocity, large pressure amplitudes, and ambient noise level in field. E. Ackerman, USA

3583. **Barkechli, M., Investigation of the harmonic intervals of the musical scale on the basis of the subjective sensitivity of the phenomenon of consonance** (in French), *Acustica* **2**, 6, 242–250, 1952.

In order to establish a relationship between the musical scale and the physical characteristics of sounds, the author resumes, in relation to the harmonic intervals, previous work which was only concerned with the measurement of melodic intervals. These experiments, in which the personal equation of the player has a certain part, confirm, in general, the results of earlier researches, viz., that there are really two scales: one the melodic scale, the other the harmonic one.

From author's summary by M. A. Heaslet, USA

3584. **Kazantseva, M. V., Absolute calibration of sound receivers by the method of reciprocity of standing waves in a pipe** (in Russian), *Zh. tekh. Fiz.* **21**, 10, 1213–1223, Oct. 1951.

This method of calibration involves two sets of measurements. In the first, the sensitivity of the receiver to be calibrated (M_x) and that of a standard transducer (M_{ob}), both used as receivers, are compared; this gives the relation $M_x/M_{ob} = E_x/E_{ob}$ (E_x and E_{ob} being the EMF's developed in the two receivers, respectively, for the same sound pressure). In the second measurements the current in the transducer used as a transmitter (I_{ob}) and the EMF developed in the receiver to be calibrated (E_x) are measured; this gives the relation $E_x/I_{ob} \times H = M_x M_{ob}$, where H, the so-called parameter of reciprocity, is the ratio of the sensitivities of the transducer used as a transmitter and receiver, respectively. From these two equations M_x can be calculated.

The apparatus used and the means of obtaining conditions required by theory are described. Results obtained for piezoelectric microphone calibrated by method of reciprocity differ by only 0.6% from those obtained by Rayleigh disk method. Similar investigations on tourmaline plate are extended to a higher frequency limit (10,000 cps) than reached in author's previous work [*Dokladi Akad. Nauk SSSR* **58**, no. 8, 1947] by using smaller-diameter tube and hydrogen instead of air.

Marie Goyer, England

Ballistics, Detonics (Explosions)

(See also Revs. 3479, 3492)

3585. **Casci, C., On the solution of the differential equations of missile flight** (in Italian), *Monogr. Lab. Aero. Politec. Torino* no. 292, 17 pp., 1952 = *Studia Ghisleriana* (4) **1**, 1952.

Author investigates equations of motion of a rocket. He indicates the wide variety of recent military rockets and the even greater variety of situations to which the study of moving propellants applies. He lists numerical data for 14 types of rocket propellants now in use. The differential equations, with separate expressions for different phases, are not finitely integrable. They depend essentially upon the weight ratio and combustion parameter. By dividing the trajectory into convenient portions and using mean values in each portion, expressions are obtained (in each portion) for velocity and distance traversed in terms of Bessel, trigonometric, and logarithmic functions. A final section considers vertical flight, ignoring air resistance.

A. A. Bennett, USA

3586. **Schaub, W., Possibilities for changing elliptical orbits into circular ones, and vice versa** (in German), *Weltraumfahrt* no. 3, 4; 81–86, 106–111, July, Oct. 1952.

Author considered elliptical orbits of a body running around the sun with different eccentricity, but with the same energy. One of them is a circle. In a point where one orbit cuts another of the same energy, the velocity is the same. For changing the one elliptical orbit into the other, it is necessary at such a point to change only the direction but not the amount of the velocity. Nevertheless, an expenditure of energy is necessary. Especially discussed is the case where the body is led along a path touching all elliptic orbits. A. Betz, Germany

3587. **Perret, E., Roth, E., Sänger, R., and Voellmy, R., Trajectories of beam-riding rockets with jet-stream steering** (in German), *ZAMP* **3**, 4, 241–258, 1952.

Equations of motion in a single plane for a beam-riding rocket are derived under assumptions of constant thrust. A radar or other electromagnetic beam locates an aircraft flying with constant velocity and altitude at a horizontal range "a," and the rocket is fired immediately. Control by means of rotation of the jet stream is considered for (1) a highly stable body, (2) a neutrally stable body, and (3) a body with aerodynamic surfaces. A numerical example treats interception of an aircraft at 5 kilometer altitude with horizontal ranges at time of radar pickup of 10 km (approaching), 4 km (approaching), 0 km (overhead), and −4 km (retreating). The steering angle, or angle between jet stream and body axis, is determined for each configuration and range at launch as a function of time. Jet-stream rotation angles were excessive for the highly stable body, a maximum of 5 to 90 deg depending on range of pickup; the neutrally stable configuration re-

quired rotation angles measured in seconds; use of aerodynamic surfaces implied thrust rotations of a few degrees.

E. T. Welmers, USA

3588. Lotkin, M., Ballistic functions related to the Newtonian law of resistance, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 31–35, 1952.

New ballistic tables have recently been computed under the direction of Schoenberg at the Aberdeen Proving Ground, U.S.A. These are extensions beyond previous tables [see Crany, "Lehrbuch der Ballistik," vol. 1, Berlin, 1925] and enable complete trajectories to be determined over a wide range of parameters.

Starting from first principles, author explains the approximations to obtain the equivalent k (constant in a v^2 resistance law). Numerical examples are given which establish satisfactory results by comparison with step-by-step integration of the trajectory. There is no reference to the publication of the tables.

R. C. Knight, England

3589. Travers, S., and Touchard, L., The gun with an internal nozzle, *Mém. artill. fr.* **26, 27,** 4, 1; 835–858, 221–236, 1952, 1953.

Authors give a detailed theoretical and practical study of the interior ballistics of guns in which the chamber pressure is kept higher than the bore pressure by an intervening nozzle. Example treated is the 8-cm PWK 43. Advantages relative to orthodox guns are discussed. J. Corner, England

Soil Mechanics, Seepage

3590. Meyerhof, G. G., and Chaplin, T. K., The compression and bearing capacity of cohesive layers, *Brit. J. appl. Phys.* **4,** 1, 20–26, Jan. 1953.

A theoretical study of the compression of blocks and cylinders of purely cohesive material between rough plates shows that the yield pressure of the blocks and cylinders increases with the roughness of the plates and with decreasing height of the specimen. Compression tests of blocks and cylinders of Plasticine and clay between rough plates are found to be in good agreement with the theory. The above analysis has been extended to obtain an estimate of the yield pressure of footings on cohesive layers; theoretically, the bearing capacity should increase with the adhesion of the material on the footing and base and with decreasing thickness of the layer. The results of some loading tests on circular and strip model footings on Plasticine layers with a rough base conform to the theory. J. N. Thompson, USA

3591. Daehn, W. W., and Hilf, J. W., Implications of pore pressure in design and construction of rolled earth dams, *Trans. Fourth Congr. Inter. comm. Large Dams,* New Delhi, Jan. 1951, in 4 vols., vol. I, pp. 259–283. $48 per set.

First part of paper ("Pore pressure in design," by Daehn) gives the results of some pore-pressure measurements on actual dams and the (usual) application of these results to stability analyses.

Second part of paper ("Pore pressure and construction control," by Hilf) considers the fundamental relationships of soil compaction and of consolidation by compression of the air voids. The Bureau of Reclamation's methods are outlined, stating that impervious soil should be placed 2% dry of laboratory optimum in order to contain a substantial quantity of air.

H. Lundgren, Denmark

3592. Shield, R. T., Mixed boundary value problems in soil mechanics, *Quart. appl. Math.* **11,** 1, 61–75, Apr. 1953.

The stress-strain law for an ideal plastic soil formulated by Drucker and Prager [AMR 6, Rev. 299] is used to obtain velocity equations for plane strain problems. The solutions of Prandtl and Hill to the problem of indentation of the soil by a strip footing are examined, and the incipient velocity fields obtained. The problem of indentation by a lubricated wedge is also solved.

R. E. Gibson, USA

3593. Capper, P. L., Soil mechanics in relation to structural engineering, *Struct. Engr.* **31,** 2, 47–61, Feb. 1953.

This paper describes the use of site exploration and tests of strength and volume change of soil to supplement experience in selecting and designing structural foundations. Interrelation between variable soils and semirigid structures is considered. Several problems which may be solved by cooperation between practicing engineers and research workers are summarized.

E. S. Barber, USA

3594. Baker, R. F., Analysis of corrective actions for highway landslides, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 190, 25 pp., May 1953.

See AMR 5, Rev. 3588.

3595. Boyer, W. C., and Lummis, H. M., Design curves for anchored steel sheet piling, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 165, 12 pp., Feb. 1953.

Analysis in terms of dimensionless ratios is presented for a wall with free earth support retaining surcharged sand submerged to the anchor level, assuming Rankine pressures. The maximum bending moment, anchor pull, and required depth of penetration are given in convenient charts in terms of depth of water, height above anchor, surcharge height, and sand density for angles of internal friction equal to 20, 30, and 40 degrees above water with values below water equal to $1/2$, $3/4$, and 1 times these values.

E. S. Barber, USA

3596. Ayers, J. R., and Stokes, R. C., The design of flexible bulkheads, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 166, 11 pp., Jan. 1953.

This paper outlines comprehensively the procedures used by the Bureau of Yards and Docks, U. S. Navy, for the design of bulkheads (cantilever, single-anchored, and double-anchored). The authors describe the computation of pressures by the classical theories, the depth of penetration required, and methods for reducing lateral pressures, i.e., the use of sand blankets, sand dikes, relieving platforms. Types and design of tie rod anchorages are discussed and the importance of the construction sequence is emphasized. Several valuable practical axioms for bulkhead construction are included.

The authors' purpose as stated is "not to advance a new procedure that will remove all uncertainties from bulkhead design," but rather to set forth the methods, procedures, and practical rules used by the Bureau of Yards and Docks. From this standpoint the paper is a very valuable summary of wide experience in bulkhead design. P. P. Brown, USA

3597. Diachishin, A. N., Hess, S. G., and Ingram, W. T., Sewage disposal in tidal estuaries, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 167, 14 pp., Jan. 1953.

Article presents information on the nature of tidal actions with emphasis on those aspects of interest to the sanitary engineer. Techniques used in determining dilution volumes and detention periods are discussed with the purpose of determining how well

these methods are in accord with accepted concepts of tidal flow.
From authors' summary by J. C. Geyer, USA

Micromeritics

3598. Wilson, B. W., The turbocyclone: a new method for separating fine particles from gas streams, *Austral. J. appl. Sci.* 4, 1, 47–57, Mar. 1953.

Particle separation in the 1–10 micron size range was effected by imparting angular momentum to the air mass containing small particles. The upstream element consisted of an axial-flow fan. The central section was the separation chamber which was the annular space between two concentric cylinders. The downstream element consisted of an axial-flow turbine. The solid and liquid particles, being greater in density than the air, were deposited on the outer periphery of the separation chamber. The particles were removed by means of a liquid film on the surface of the separation chamber. The equipment was laboratory-tested with glass spheres 0.5–50 microns in diameter in an air stream. Field tests were performed on sodium-sulphate fumes from a paper mill and on the exit gases from a contact sulfuric-acid plant.
M. R. Carstens, USA

Geophysics, Meteorology, Oceanography

(See also Revs. 3294, 3337, 3570)

3599. Handin, J., An application of high pressure in geophysics: Experimental rock deformation, *Trans. ASME* **75,** 3, 315–324, Apr. 1953.

The paper reports on the geophysical problem of rock deformation in which there is an application of high pressure. Previous work as well as experimental studies at the University of California and at the Shell Laboratories are described. Of special interest is the instrumentation developed at the Shell Laboratories for tests of short duration with confining pressure to 10,000 atm and temperature to 400 C. Creep-testing equipment providing for runs of several hundred hours at confining pressures to 3500 atm and temperatures to 500 C is being constructed.

Some of the main observations on natural rock salt are summarized as follows: (1) The salt has a remarkable ductility in compression, even at very low confining pressures. (2) Initially, there is either no elastic limit or yield point, or it is too low to be detected. (3) Deformation results in work-hardening. (4) The increase of strength and ductility with confining pressure, so striking with many rocks, is much less pronounced in the case of salt.

An extensive list of references is appended.
R. K. Bernhard, Norway

3600. Ergin, K., Amplitude of *PcP*, *PcS*, *ScS*, and *ScP* in deep-focus earthquakes, *Bull. seism. Soc. Amer.* **43,** 1, 63–83, Jan. 1953.

This paper extends the work of Dana [title source, **34, 35,** 189–197, 27–35; 1944, 1945] and Martner [AMR **4,** Rev. 956] to consider a group of deep-focus earthquakes recorded at Pasadena. The study reveals that the observed ratios of the horizontal components of the waves that are reflected as *P* waves (*PcP*/*P* and *ScP*/*S*) and that of the vertical component of waves that are reflected as *S* waves (*ScS*/*S* and *PcS*/*P*) are considerably larger than the theoretical ratios. The ratios of the vertical components of the first group and the horizontal components of the second are, however, in fairly good agreement with theory. This would imply that the vibration of the ground is not in the direction of propagation for *PcP* and *ScP*, nor transverse to the direction of propagation for *PcS* and *ScS*. Author discusses the difficulties and indicates that further work is required.
J. M. Jackson, Scotland

3601. Hodgson, J. H., and Storey, R. S., Tables extending Byerly's fault-plane techniques to earthquakes of any focal depth, *Bull. seism. Soc. Amer.* **43,** 1, 49–61, Jan. 1953.

Byerly developed a technique for obtaining the direction of faulting in a normal-focus earthquake from the data of the distribution of initial motions [title source, **16, 24, 28,** 209–265, 1926; 81–99, 1934; 1–13, 1938. *Amer. J. Sci.* (5) **16, 19,** 232–236, 274–282]. Hodgson with Milne reviewed and extended the above method in an earlier paper [AMR **5,** Rev. 301]. Also, Stechschlte devised a way to obtain travel-time curves for an earth stripped to any focal depth.

Combining above papers, authors apply Byerly's original theory to the stripped earth to the depth of focus and thus enable us to get a fault plane of deep-focus earthquake. Necessary values are listed in tabular form. Y. Satô, Japan

3602. Thompson, P. D., On the theory of large-scale disturbances in a two-dimensional baroclinic equivalent of the atmosphere, *Quart. J. roy. meteor. Soc.* **79,** 339, 51–69, Jan. 1953.

Author develops fundamental equations of nonviscous flow so as to apply to a two-dimensional baroclinic equivalent of the true atmosphere. Method for solving these equations is outlined. Stability criterion for horizontally uniform flow with constant vertical wind shear is derived and results compared with earlier development of Fjörtoft for three-dimensional baroclinic flow. The method applies to deep atmospheric layers and provides a new basis for numerical weather prediction.
J. M. DallaValle, USA

3603. Arakawa, H., Tilted-trough model as an interaction between low- and high-latitude disturbances, *J. Meteor.* **10,** 1, 64–66, Feb. 1953.

Rossby's theorem of conservation of the vertical component of absolute vorticity in a nondivergent flow in an incompressible ideal fluid leads to a simple two-dimensional vorticity equation. Author solves this equation for constant β by means of a stream function which describes a wave model consisting of troughs and ridges tilted with respect to the W-E direction. The model gives a meridional transport of momentum and energy. It also seems possible to study the interaction of low- and high-latitude disturbances with the help of this model. H. Merbt, Sweden

3604. Bose, N. K., and Nag, S. K., Design rain storm for Damodar Catchment, *Trans. Fourth Congr. Inter. comm. Large Dams,* New Delhi, Jan. 1951, in 4 vols., vol. II, 791–803. $48 per set.

Statistical analysis of rainfall data in a specified case is presented. For the method applied, authors refer to Gumbel, E. J., "The return period of flood flows" [*Ann. Math. Statist.* **XII,** 1941]. "Average return period" is used as independent variable for the distribution of annual maximum values. Some justification of the exclusive use of annual maxima is given.
H. J. Schoemaker, Holland

3605. Best, A. C., Condensation nuclei and the development of radiation fog, *Quart. J. roy. meteor. Soc.* **79,** 339, 112–120, Jan. 1953.

The growth of liquid-water droplets upon condensation nuclei

as the relative humidity rises from 80% to 100% is examined. It is assumed that the condensation nuclei consist of sea-salt particles and that the droplets are always in instantaneous equilibrium with the ambient relative humidity. An arbitrary nucleus-size distribution formula, which is easily adjusted to fit an intuitively reasonable size distribution, is also assumed. It is found that the shape of the nucleus-size distribution curve has very little effect upon the computed value of the liquid-water content W of the fog, though at saturation W varies as the square root of the mean mass of the nuclei. In near-saturation conditions a small variation in relative humidity has a big effect upon W.

A formula for drop-size distribution in fog at saturation is developed and found to agree with measurements.

Visibility in the developing fog is briefly considered, and it is shown that Koschmieder's formula, applied to the growing water drops, leads to results consistent with experience. Neither the mean nucleus mass nor the shape of the nucleus-size distribution curve affects the visibility at saturation.

From author's summary by W. C. Johnson, Jr.

3606. Mason, B. J., The growth of ice crystals in a supercooled water cloud, *Quart. J. roy. meteor. Soc.* **79,** 339, 104–111, Jan. 1953.

The new feature of this paper is a report on some laboratory experiments on the growth rates of ice crystals in a supercooled water cloud between temperatures of 0 and −10 C, supplementing previous work by S. E. Reynolds [*J. Meteor.* **9,** 36–40, Feb. 1952] which dealt with temperatures −20 to −15 C. The author recapitulates previous theoretical work on crystal growth rates (with some minor refinements) and attempts to check the growth-rate predictions from his laboratory work. Reviewer believes both the method of checking and the degree of agreement leave a lot to be desired.

Joanne S. Malkus, USA

3607. Miyazaki, M., On the relation among wind speed, tangential stress and roughness of the sea surface, *Oceanogr. Mag., Tokyo* **3,** 1, 17–21, Mar. 1951.

3608. Miyazaki, M., Mathematical studies of surf and breakers. Nonlinear wave theory in shallow water of constant slope, *Oceanogr. Mag., Tokyo* **3,** 2, 65–74, June 1951.

3609. Miyazaki, M., Averaged wind-stress relation on the sea surface, *Oceanogr. Mag., Tokyo* **3,** 2, 75–77, June 1951.

3610. Miyazaki, M., Notes on the theory of the wind-driven oceanic circulation, *Oceanogr. Mag., Tokyo* **4,** 2, 31–36, Oct. 1952.

The Munk equation for mean ocean circulation due to wind stress is based on the assumption of a lateral eddy viscosity which is independent of position. In this paper the lateral eddy viscosity is assumed to decrease sharply near the western edge of the ocean. Solutions to this revised problem evidence a western countercurrent suggestive of the observed fluid motion. The arbitrariness of eddy conductivity assumptions necessitates a model or mechanism to justify them. Here the author suggests that nearness to a coast restricts "mixing lengths." The author does not deduce or discuss the cross term which would arise in a rederivation of the Munk equation appropriate to his assumptions.

W. V. R. Malkus, USA

3611. Ichiye, T., On the variation of oceanic circulation, *Oceanogr. Mag., Tokyo* **4,** 2, 37–47, Oct. 1952.

Third empirical part of theoretical study on monthly variation of Pacific circulation produced by winds.

H. Stommel, USA

Lubrication; Bearings; Wear

3612. Murray, S. F., Johnson, R. L., and Bisson, E. E., Effect of high bulk temperatures on boundary lubrication of steel surfaces by synthetic fluids, *NACA TN* 2940, 27 pp., May 1953.

Survey showed that a silicate ester offered more promise than the other lubricants studied. Phosphonate esters form products that are corrosive to steel but which prevent complete lubrication failure. Diesters, polyalkylene glycols, esters of inorganic acids, silicones, and silicone diester blends are compared with petroleum oils on basis of friction force, surface failure, and bulk lubricant thermal stability.

E. F. Macks, USA

3613. Lunn, B., Some experiments with sleeve bearing metals, *Trans. Dan. Acad. tech. Sci.* no. 2, 137 pp., 1952.

To date, very little theory has been advanced to explain what properties metals must possess to make good bearing materials and what properties oils must possess to be good lubricants. Author uses new test method and compares results with existing practical knowledge of widely used bearing metals. Good correlation is obtained which prompts formulation of a new hypothesis explaining function of sleeve-bearing materials. Hypothesis stresses importance of presence of surface films produced by chemical reaction between metals, lubricant, and atmosphere to the successful functioning of a sleeve bearing. Bearing properties of metals and oils thus depend on their ability to react with other components and atmosphere to form adhesive films which prevent metallic contact.

Apparatus produces controlled boundary lubrication by allowing a steel ball to slide on a plane test piece immersed in lubricating oil. Ball motion is reciprocating with maximum speed of 0.5 mps. Load for ordinary white metals tested was on the order of 1200 kg/cm². A low voltage was impressed across the contact point and a recording voltmeter used to record resistance conditions during test. A curve of mean voltage against time is thus obtained. The area between the curve and the line representing impressed voltage indicates contact time during test period. This value expressed as a percentage of test time is termed "L-value." The lower the L-value, the better the bearing metal - oil combination.

Metals tested include a wide variety of lead and tin-base babbitts and various copper alloys. Tests of grain-size significance reveal that fine grain structure obtained by rapid solidification gives best results. Lead-base babbitts were found superior to tin base. Tests of copper alloys show that presence of phosphorus improves bearing properties (as measured by L-value).

Several tests of oils are reported, but this reviewer believes that more tests must be conducted before it can be determined whether the apparatus is sensitive enough to evaluate different oils.

Reviewer believes that this work is a worth-while contribution to the bearing and friction field in that it presents a laboratory method for evaluation of bearing metals and oils which eliminates necessity for full-scale bearing tests to obtain data. Reviewer believes, however, that test specimen cleaning procedure can be improved. It has been found by Campbell [*Trans. ASME* 61, 7, 633–641, 1939] and others that no solvents alone can degrease a metal surface, even when freshly distilled. Rather, a cleaning procedure involving scrubbing with an abrasive-water mixture,

several alcohol rinses, and very careful drying must be used to insure grease-free surfaces. Slightest grease contamination can markedly affect results. W. J. Anderson, USA

3614. **Godfrey, D., and Bisson, E. E., Bonding of molybdenum disulfide to various materials to form a solid lubricating film. II—Friction and endurance characteristics of films bonded by practical methods,** *NACA TN* 2802, 16 pp., Oct. 1952.

Note describes experiments to determine the friction and durability of films of molybdenum disulfide on surfaces of several materials using various binder materials. Friction was measured at sliding speeds from 75 to 8000 fpm with an initial Hertz stress of 126,000 psi between the flat disk and the hemispherical rider. Endurance was measured with increasing load increments at a constant sliding speed of 445 fpm with the rider always tracking in the same path.

Results indicate good performance with asphalt and silicone-base varnish and glycerol and corn-syrup resin as binders. Film thickness used ranged from 0.0002 to 0.0005 in. Friction was low with all of these binders except at low sliding velocity. Endurance compares favorably with silver and cadmium plate of comparable thickness under their test conditions.

All tests were conducted with a mixture of one part MoS_2 to two parts of vehicle by weight. It would be interesting to learn how this ratio affects the performance of the film. The process appears useful for surfaces difficult to lubricate by usual means. The MoS_2 serves as a boundary lubricant, with the binder providing a much more durable film than is possible with the unbonded material. J. B. Bidwell, USA

3615. **Sedney, R., Charnes, A., and Saibel, E., The Reynolds lubrication equation with smooth outflow,** Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 875–881, 1952.

Solutions of Reynolds equation without side leakage are considered for boundary conditions defining smooth outlet flow from the film. This condition exists when the rate of change of pressure at outlet in the direction of flow is zero, and was used by Vogelpohl who took $p = 0$ at inlet and outlet of the film and $dp/d\theta = 0$ at the outlet. The present authors take as boundary conditions $p = 0$ at inlet and $p = k\,dp/dx$ at outlet. These are shown to be natural boundary conditions by variational principles. Smooth outlet flow results if $p = 0$ at the outlet for a nonzero value of k.

In a converging film, it is shown that the boundary condition can only be satisfied for $k = 0$. Thus, smooth inlet flow is not possible for this case.

In the case of the journal bearing, it is shown that the condition can be satisfied for any value k, and hence a more general expression for the condition of smooth outlet flow is obtained than that given by Vogelpohl.

Finally, the converging diverging film is considered, and the conditions are determined for a smooth outlet flow with only positive pressure in the film. W. O. Richmond, Canada

3616. **Gibney, J. J., Jr., Large steam turbine-generator lubricating systems,** ASME Ann. Meet., New York, Dec. 1952. Paper 52—A-152, 6 pp.

Paper describes the practices used by one turbine manufacturer to reduce to a minimum the hazard of oil leaking or spraying on steam pipes. Also described is the protection available for hydrogen-cooled generators to prevent possible oil-reservoir explosions. From author's summary

Marine Engineering Problems

(See also Rev. 3336)

3617. **Horn, F., Contribution to the theory of turning maneuvers and directional stability** (in German), Berlin, Springer-Verlag, Jahrbuch Schiffbautechn. Gesellschaft **45**, pp. 78–101, 1951.

By choosing coordinate axes (moving with the ship) along the tangent and the normal to the path of the c.g. and considering motion only in the horizontal plane, the equations of motion with constant magnitude of velocity v along the tangent are simply $M''v^2/r = Q$; $I'd\omega/dt = M$, where Q is the total force along the normal and M the moment about a vertical axis. Force and moment are expressed by the linearized equations $Q = A\delta_0 - B\omega/v + C\beta$; $M = D\delta_0 - E\omega/v + F\beta$, where δ_0 is the angle of yaw at the c.g., ω the angular velocity, and β the rudder angle. It is shown that $B = D$ and that for an arbitrary point of the ship the angle of yaw (angle between longitudinal axis of ship and tangent to path of point) is $\delta = \delta_0 - x\omega/v$, where x is distance of point from c. g. The importance of the last term is emphasized.

With $\omega = v/r + d\delta_0/dt$, r being radius of curvature of path, and constant rudder angle, ordinary second-order differential equations are obtained for δ_0 and ω. Numerical results are given for some idealized cases with a high-speed boat with only two narrow lifting surfaces and the rudder in the water. For buoyancy ships it is necessary to make model experiments to measure the magnitude of the coefficients in the above expressions.

G. Vedeler, Norway

3618. **Kapryan, W. J., and Weinstein, I., The planing characteristics of a surface having a basic angle of dead rise of 20° and horizontal chine flare,** *NACA TN* 2804, 42 pp., Oct. 1952.

Steady-state planing surface characteristics were measured in a towing tank at Froude numbers between 3 and 25. Tests were conducted at model trim angles up to 30° for loadings which produced wetted length-to-beam ratios up to 7.

Data are presented on chine and keel wetted length and compared to theory. The effect of buoyancy at low speed and low load conditions is discussed, and the variation of draft with loading and trim angle is shown.

Center of pressure positions is apparently independent of trim angle below 18°, and it is shown that, for the smooth model used, the induced drag gives the principal contribution to resistance at the higher trim angles. This author concludes that high-speed planing characteristics depend only on lift coefficient.

H. M. Spivack, USA

3619. **Miller, R. W., Water-landing investigation of a flat-bottom V-step model and comparison with a theory incorporating planing data,** *NACA TN* 2932, 23 pp., May 1953.

Computed results obtained according to the method presented in *NACA TN* 2814 for the calculation of hydrodynamic impact loads by the use of force-draft relationships obtained in planing are compared in time-history plots with experimental impact data. These comparisons show good agreement and indicate that this method can be applied successfully to the impact of V-step models having high beam loadings.

From author's summary by M. P. O'Brien, USA

3620. **Conn, J. F. C., Lackenby, H., and Walker, W. P., B.S.R.A. resistance experiments on the "Lucy Ashton." Part II,** *Shipbuilder* **60**, 538, 321–332, May 1953.

Paper deals with correlation of the measured full-scale resistance of a 190.5-ft ship with the model-basin test results of six

geometrically similar models from 9 to 30 ft in length. As such, it gives the most important ship-model correlation data since William Froude's classical "Greyhound" experiments in 1871. The ship resistance at various speeds is obtained by measuring the thrust of four aircraft jet engines on deck, applying corrections fully accounted for in paper. Extrapolation from model to full-scale results of smooth hull is effected by using Froude's coefficients and more modern formulations, viz., Schoenherr, Prandtl-Schlichting, and Telfer. Hull-surface roughness measurements are analyzed for four naked-hull conditions. Best correlation for all speeds was obtained by Schoenherr's and Prandtl-Schlichting's formulations, yielding an average roughness allowance for the normal service condition of 0.3×10^{-3} on the smooth frictional coefficient. Froude's coefficients showed a much wider variation in the prediction from the various models at low speeds, but rather satisfactory results with increasing speed. Full details of all results are given in appendixes.

A modification of modern conceptions of flat-plate skin-friction formulation for three-dimensional flow appears to merit serious consideration. Since the 9-ft model as tested in a large model basin did not yield accurate results, reviewer believes that the extrapolation procedures as adapted by the authors could be materially improved in the low Reynolds number range by additional testing of small models (5 ft) with adequate instrumentation.

For naval architects this is a most important and stimulating paper. L. Troost, USA

3621. Cockcroft, Sir John, Atomic propulsion—with special reference to marine propulsion, *Trans. Inst. mar. Engrs.* 65, 4, 105–110, Apr. 1953.

Using released information from British, Canadian, and U. S. sources, the author discusses the application of atomic energy to ship propulsion. He discusses first the general theory of reactors, including build-up time and control. From here he proceeds to a brief discussion of kinds of reactors. He gives brief consideration to the technical problems and compares the expected fuel cost of an atomic propulsion power plant with that of the conventional plants. He concludes by a consideration of the feasibility of nuclear propulsion for shipping, and concludes that they will operate successfully and will be worthwhile for special applications such as the submarine. F. E. Reed, USA

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